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Some Notes on Steamship Economy.

THE problem of steamship economy is one which demands the closest attention of engineers, shipbuilders and shipowners.

The enormous cost of building fast vessels, such as Atlantic liners, has been forced on public notice within the last few years, owing to the keen competition between the great maritime powers for supremacy on the high seas.

It is the intention in the following article, however, to confine our attention particularly to the more common type of vessels known as the "ocean tramps," for notwithstanding the very much lesser speed, the requisite power, and consequently coal consumption, occupies a very prominent place in determining the type to be selected.

In all steamers the largest item of expenditure is the coal bill, and is one which offers much food for thought to all connected with shipping.

The requirements of form, power and speed are so closely interwoven that only with careful study can one arrive at a reliable conclusion as to what is the most suitable amount for the particular trade in which the vessel may have to engage.

The tendency within the last few years has been to construct ships having very full forms—so that the relation between a modern steamer and a box of similar circumscribing dimensions is not so very closely defined as was formerly the case.

The effect of this on the power required to drive at a reasonable speed, and the most economical speed at which the ship may be driven, has been the topic of much controversy; further, the power which has been found adequate under fair weather conditions has, in many instances, utterly failed to maintain headway in the teeth of a gale. Instances are by no means rare of vessels capable of steaming nine or ten knots ordinarily, making an average speed of four knots per hour across the Atlantic in heavy weather.

Distinct again from such external conditions, an examination of the machinery, in order to ascertain the efficiency of the many working parts and possibilities of improvement, contains much scope for interesting research, and would no doubt, if indulged in more frequently, result in some interesting facts being brought to light.

Such investigations are, unfortunately, very much hampered by the scarcity of reliable data obtainable and in many instances the uncertainty as to its accuracy; however, with a reasonable amount of care, the salient features may easily be deduced and valuable lessons derived therefrom. Further, a great drawback is that very few ships are run on trial under full load, with the result that in many cases the propeller works only partially submerged and consequently decreases the efficiency to a very marked extent.

The ideal method of obtaining data would be by perusing engineers' logs made over a series of voyages; but here again the same difficulty presents itself, as very few engineers will give a full account, they merely contenting themselves by entering their best runs.

I have based my conclusions, as far as possible, on figures obtained from logs; but in any case, granted similar conditions, it is permissible to assume figures so derived as correct for comparative purposes.

Up to the present coal has held, and holds, undisputed sway for the purpose of raising steam. Recently, however, owing to the energy and foresight of many of our leading commercial and technical men, oil is being looked upon as a possible rival.

Until within the last few years, the greatest objection was that oilfields were confined to a more or less restricted area, thus very few efforts were made to adapt it for steam-raising purposes. Now, however, that difficulty is being overcome, as oilfields are being discovered in many parts of the world.

The advantages of oil as a fuel are self-evident—cheapness, cleanliness, and easy stowage being among the most prominent, although as yet, a really reliable and satisfactory method for burning it has to be devised. No doubt in the near future it will come to be regarded as the staple fuel, since, vast as our coalfields are, a time will necessarily arrive when the output must be restricted, owing to the exhaustion of supply caused by the enormous demands made upon them.

The quality of coal used is the most important item as regards raising steam. In the course of long voyages, when it is impossible to take on board an adequate supply, steamers are compelled to re-bunker at foreign ports, where the quality obtainable leaves very much to be desired, thus causing, even with the most carefully constructed boilers, a wide range of efficiency, besides the cost in many instances being excessive.

For trading purposes the ordinary Scotch boiler still retains favour—whether owing to its inherent qualities or otherwise is a matter of private opinion. Certainly its reliability and durability under many varied conditions of service justify the faith placed in it; but no doubt in the near future we may hope to hear of some other kind which can be substituted with an increased efficiency whilst retaining all the important qualities which characterise the Scotch type.

Great advances have been made in steam pressure within the last thirty years. In 1870 the average was about 52 lbs. per sq. in., whereas now it has reached 160 lbs. to 180 lbs., even in some cases as much as 200 lbs., per sq. in., particularly when quadruple expansion engines have been fitted. Increase of pressure has meant that a very much higher degree of efficiency has been obtained. The amount of coal burnt per indicated horse-power per hour has been reduced from 5·5 to between 1·5 and 1·7. Interpreted into language most easily understood by the investing public, this means that the coal bill has been reduced by about 70 per cent., which enables the space which would otherwise be utilised as bunkers to be thrown into the cargo hold, thereby increasing the value of the ship from a money-earning standpoint of view.

The efficiency of a boiler is determined by the amount of coal which can be burnt per square foot of grate area, and the evaporative power of the fuel. Any increase in coal consumption per square foot of grate surface enables smaller boilers being fitted. In order to attain this end different systems of forced or induced draught have been adopted. No—or, at any rate, very little—increase of cost is entailed by this system; and incidentally it is a distinct advantage as regards the ship's structure, as it obviates the necessity of cutting a large opening in the deck immediately over the boilers for leading funnel uptakes, thus preserving greater continuity of strength and doing away with the additional compensation otherwise necessary.

Coincident with improvement in boilers there has naturally been an advance in engine construction. In place of the old compound and single-expansion engines those having a greater number of expansions have proved themselves to be more

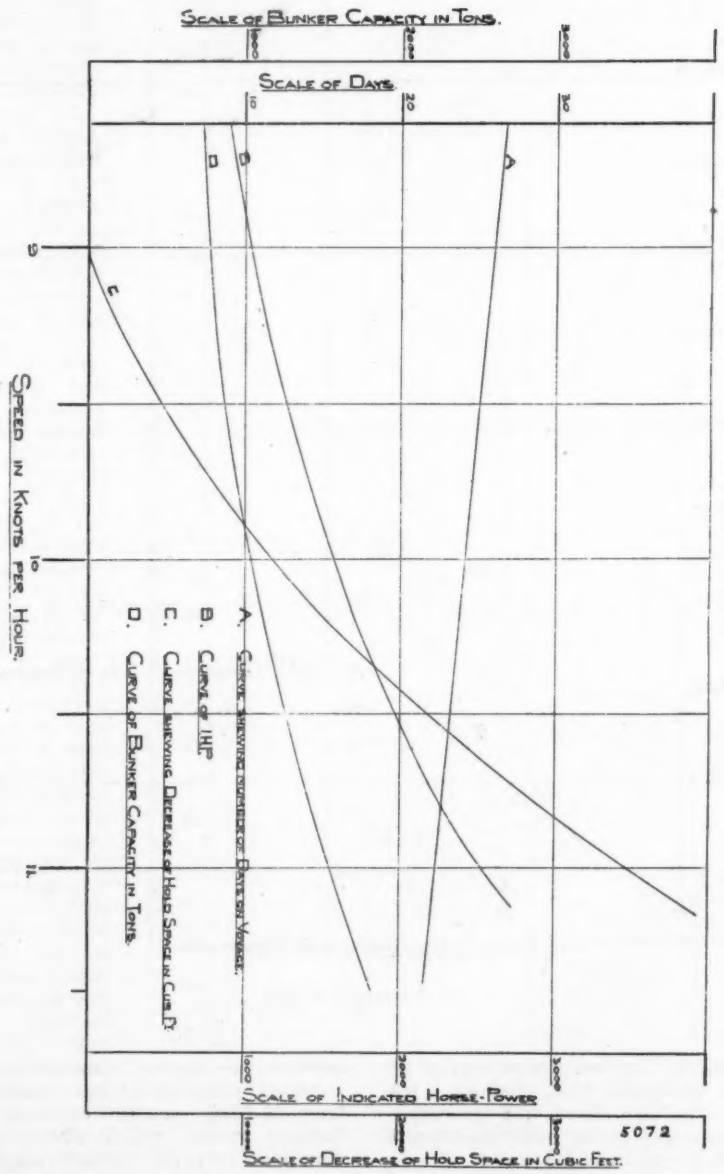

Scale of Bunker Capacity in Tons.
Scale of Days.
Speed in Knots per Hour.
A. Curve showing number of days on Voyage.
B. Curve of I.H.P.
C. Curve showing Decrease of Hold Space in Cubic Ft.
D. Curve of Bunker Capacity in Tons.
Scale of Indicated Horse-Power
5072
Scale of Decrease of Hold Space in Cubic Feet.

FIG 1.—STEAMSHIP ECONOMY.

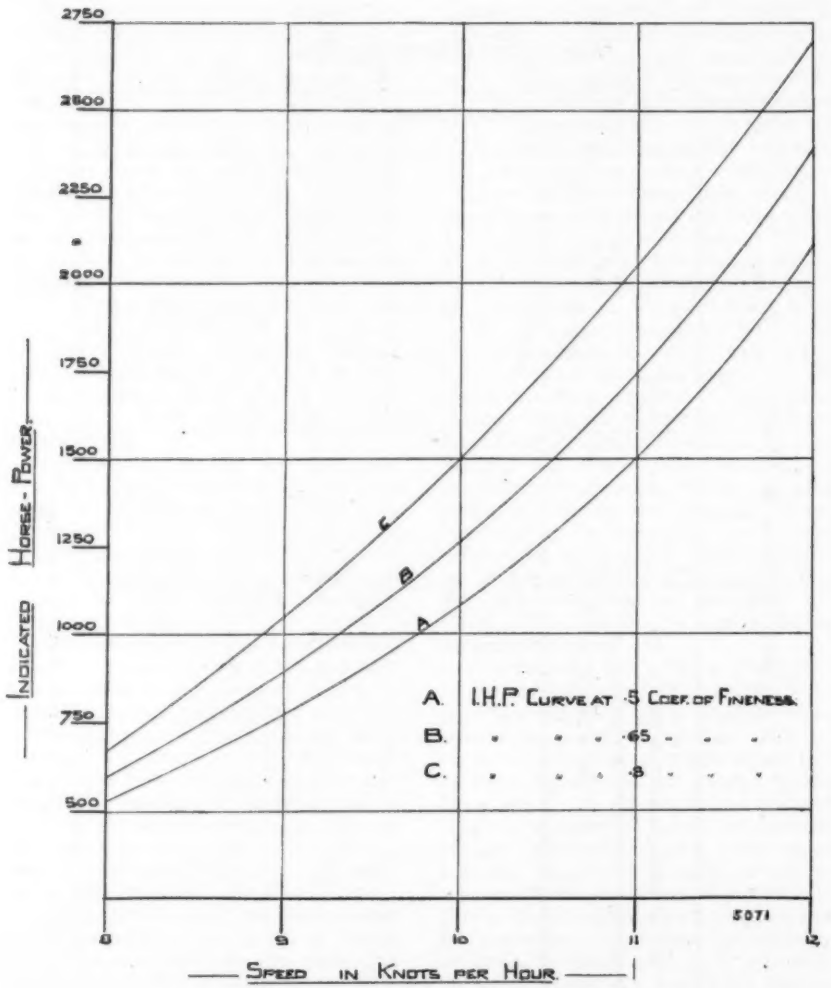


FIG. 2.—STEAMSHIP ECONOMY.

economical. Triple-expansion engines are almost universally built, although a few ships have been fitted with quadruple-expansion ones having steam pressures of 200 lbs. per sq. in. and over.

Other features which have marked advance in engine construction, are increased piston speed and revolutions, thus enabling smaller cylinders and lessened stroke, which directly affect the space occupied by and weight of propelling apparatus, and a much higher

degree of efficiency being possible, owing to the greatly decreased extent of frictional surfaces.

All engines, no matter how careful the workmanship, must suffer a decrease in the power supplied to the propeller, owing to this factor.

It is most desirable that extended experiments should be made as to the actual amount of power required to overcome this initial friction, as it is termed. So far as the writer has been able to ascertain, there is a considerable range in this loss. A well-constructed modern marine engine, driving its own pumps, ought not to show a greater defect than 20 per cent. at most; nevertheless, such results as can be obtained, indicate that this is in many instances exceeded. It would be a comparatively easy matter

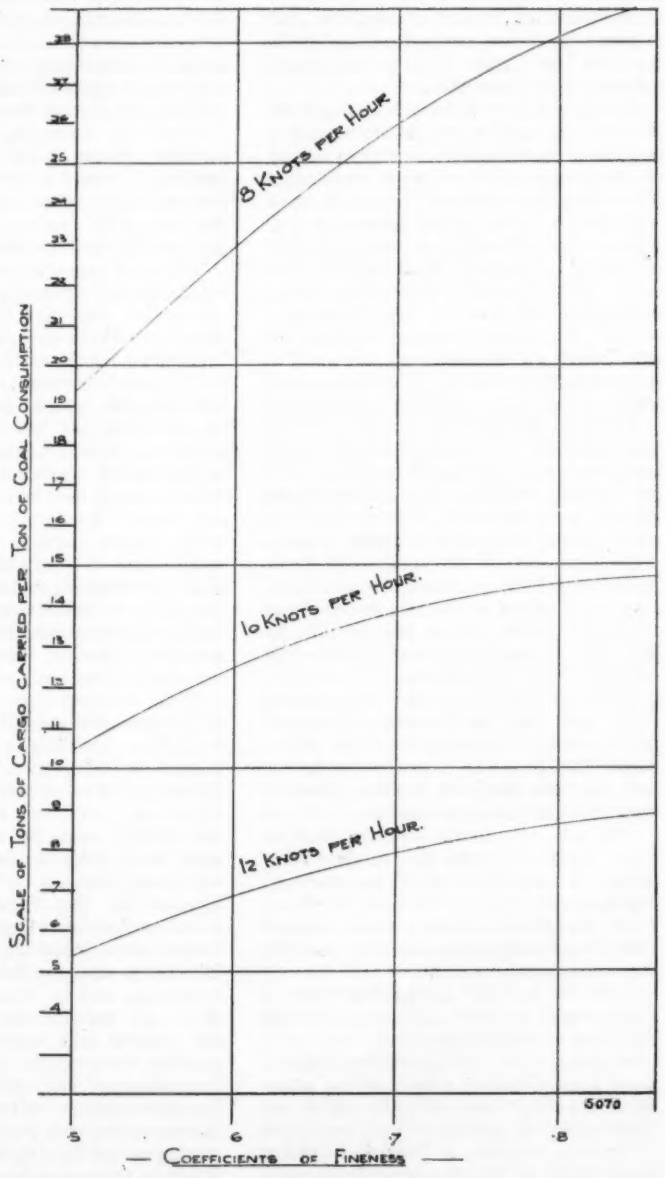


FIG. 3.—STEAMSHIP ECONOMY.

when the engines are erected in the shops, to run them at various revolutions, and measure the horse-power developed with no load, or, better still, to run them uncoupled on board ship.

Basing friction on horse-power developed per ton of machinery, which seems a rough-and-ready but fairly accurate method of comparison, this view is confirmed. The writer has found this to vary from 3·75 to 5·0, whilst a fair average is 4·5. Nevertheless, allowing for a wide range of efficiency, a marked improvement has been effected within the time before mentioned. So far as I have been able to find, the results obtained by the late Mr. Froude are the only ones on record of engines built at that time, and they only show from 50 to 60 per cent. efficiency.

Beyond reasonable care in workmanship, the possibility of keeping friction at a minimum does not seem apparent with the existing engine. One feature which strikes one somewhat forcibly is the columns supporting the cylinders. Some engineers invariably fit double slide faces involving two heavy columns to each cylinder, whilst others, at any rate in engines of moderate power, only fit one, the remaining side being supported merely by comparatively slight pillars.

Practical experience does not tend to show that the heavy-columned engine possesses any advantage over the other, whilst the latter is undoubtedly lighter and has less frictional surfaces, besides being infinitely more accessible.

The sole cure which suggests itself to one's mind is a reduction in the multiplicity of moving parts of reciprocating engines, such as is attained in direct rotary engines, which have been adopted with conspicuous success in some modern war and passenger ships.

Allowing 20 per cent. initial loss of horse-power, 80 per cent. remains to be delivered to the propeller.

A great deal of criticism has been passed upon shipbuilders as a body for the somewhat ungainly forms of hulls which are constructed at present. The coefficient of fineness or ratio of immersed portion of the hull to that of a box of the same dimensions of length, breadth and draught has reached a very high figure. Ships with coefficients of ·76 to ·8 and even over are constantly being built. These involve extremely square midship sections, with long lengths of parallel middle body and short lengths of entrance and run.

It will be interesting at this point to examine the conditions which must be fulfilled to build a paying vessel under the exigencies of modern trade, in order that we may form an idea as to the justifiability of such charges.

The most important feature to be borne in mind in designing ordinary cargo carriers of moderate speeds is that the maximum deadweight must be carried on the lightest weight of engines and hull.

It is uneconomical to introduce high speeds in this type of vessel, as the power to be developed for increase of speed advances by laws higher than the square of the speed beyond a certain amount, thus involving heavier engines and boilers and much greater coal consumption, which makes serious inroads on hold spaces, as a considerable proportion must be devoted to increased length of engine and boiler space, and sufficient bunker capacity must be provided in consequence of greater consumption; besides, it materially increases working expenses.

Due attention must be given to the requirements of strength of hull, stability, etc. The scantlings are determined by means of numbers derived from the dimensions from tables compiled by the registration societies, so, in order that the weight may be as light as possible, it is desirable to keep down the numbers, consequently dimensions. Any increase in the fineness of the hull would necessitate a larger ship being built for the same deadweight capacity, thereby increasing the numbers governing the scantlings, and so resulting in a heavier ship. So that for low speeds, by fining the model and increasing dimensions thereby, the amount of saving introduced in resistance and propelling power is incommensurable with the very much increased first cost and working expenses.

During motion through water a ship has two primary resistances to overcome —skin and wave-making. There are

others of minor importance which do not affect power to any very appreciable extent.

Fulness of form naturally means large wetted surface upon which, in conjunction with the condition of the ship's bottom, is dependent the first-named item of resistance.

Since water is not a perfect fluid, a body having motion in it exerts a dragging influence varying in extent upon speed and condition of surface. This for low speeds is by far the most important item of resistance.

The second loss is of much less magnitude. For ships of such sizes and speeds under consideration, say from 300 ft. to 400 ft. long and 8 to 10·5 knots, wave-making is hardly appreciable until 7 to 8 knots is reached, and thus at full working power it will be seen that it cannot attain any great amount.

The theory upon which investigations of external resistances are based is that the water moves in parallel layers or stream lines.

Considering a ship in such a fluid, it is evident that the motion is at once interfered with. The stream lines are deflected from their original path by the bow, producing an excess of pressure which is absorbed by increase of velocity, causing the water in the neighbourhood of the bow to be elevated above the normal.

During forward motion these elevations or waves are constantly left behind, thus causing a constant drain on the power by maintaining them.

When the stream lines pass the shoulder, change in direction is at once again set up, having just the reverse effect to the motion at the bow. The pressure decreases in varying extents as the speeds, causing a hollow or series of hollows, depending on the ratio of speed to length of parallel middle body.

The action at the stern is similar to that at the bow; thus it is evident two distinct series are created—bow and stern waves, having a more or less divergent course depending in extent upon angles of entrance and run; and the hollow or series of hollows found in way of straight sides which are the natural sequences of elevations at bow and stern.

It is apparent from tank experiments that the power absorbed in maintaining wave systems at low speeds is of minor importance. Such being the case, it is not necessary to give it special prominence by making a fine model, as there are more important features to fulfil, though it must be borne in mind that for every knot of increase in speed a greater proportion of total power is absorbed. At ten knots I have found, from formulæ based on tank experiments, the ratio of wave to skin resistance is 1 to 2·5, whilst at 14 knots it decreases to 1 to 1·5.

The remaining factor to be dealt with is the propeller.

We have already seen that only about 80 per cent. of the power indicated in the engines is transmitted to the propeller; only a portion of this is utilised in overcoming ship resistances.

In briefly describing skin resistance it has been stated that the hull exerts a drag on the surrounding water, thus imparting to it a speed bearing a certain proportion to the speed of the ship. So that the propeller is actually working in a stream of water of forward motion, termed the "wake," the speed of which varies as its distance from the hull. This presents a problem incapable of mathematical solution, but for all practical purposes it is sufficiently correct to assume it to have a constant velocity.

The propeller being thus placed in a stream of water of forward motion, gains a certain amount of power from it; but against this apparent gain must be set another loss.

Its action in projecting a mass of water aft exerts a sucking tendency on the water on the fore side of it or that along run of the ship, which causes an increase of velocity, and consequently defect in pressure. So that the pressure on the run, instead of counterbalancing the pressure on the entrance, is, to a certain degree, less. This subsidiary resistance is termed "thrust deduction," or "augmented resistance." The ratio between this thrust deduction and wake gain indicates the effect on ship resistance, and is termed "hull efficiency."

Experiments are wanting, with merchant ships, by which we may determine the

extent of this loss. According to text books the effect of thrust deduction to wake gain in moderately fine ships is to practically neutralise it, so that hull efficiency is *1*. On the other hand it seems that with bluff steamers under consideration, where the run has, in many instances, a very great angle, the resistance is augmented considerably, and thus sensibly depreciates the value of hull efficiency. Indeed, the writer is of opinion that the average values range between 93 to 95 per cent. or even lower.

On examination, propellers show a very wide range of efficiency. Until comparatively recently this factor has been regarded with a great amount of distrust, and as one from which satisfactory results could only be obtained by trial and error. Now, however, thanks to many able investigations made by scientific men, it has been reduced to a problem fairly capable of mathematical solution. It has been amply demonstrated that a propeller of given type can only work under certain conditions economically, and that it is quite within the bounds of possibility to design one to fulfil any given condition.

The dimensions of a propeller are naturally determined by the load draught of the ship, its fineness, and speed. In order to develop maximum efficiency, it is necessary that it should be well submerged, as otherwise it would either be partially so or so near the surface of the water as to break it, thus causing an admixture of air and water, which greatly impairs thrust. Therefore the diameter should, whenever possible, be less than draught; unfortunately under the varied conditions of service it is impossible at all times to ensure complete submersion—as, for instance, when a ship is running to or from a port in light condition.

It is to be regretted that shipowners, as a body, cannot be brought to appreciate the fact that, although first cost is greater, it is more economical in the long run to provide a greater amount of water ballast capacity, since greater immersion is attained, which enables the propeller to work with greater efficiency, besides greatly enhancing the power of the ship to maintain headway in the teeth of a gale.

The practice of some ship-owners of fitting deep tanks before or abaft the engine-room bulkheads, in addition to the ordinary cellular bottom tanks—capable of holding from 1,500 to 2,000 tons of water, is to be commended, for whilst giving superior sea-going trim it in no way detracts from cargo space, as these compartments can at any time, if so desired, be utilised for carrying cargo. Further, the effect on sea kindliness can only be fully appreciated by those who have undergone the horrors of light ship in a seaway.

The ideal ship would be one provided with sufficient water ballast capacity to immerse her to within a considerable proportion of her load draught when in light condition, and determine propeller dimensions from that draught; this would necessitate a smaller propeller being fitted, and running the engines at a greater number of revolutions.

In vessels, such as we are dealing with, the pitch should be about the same as the diameter, so as to minimise the amount of rotation imparted to the race, which causes a distinct loss of thrust. The ideal propeller would be one which would project a stream of water aft without rotary motion. With the present medium this is unfortunately impossible, and it will be readily understood that the nearer the pitch approaches a fore and aft line—or the greater the pitch—the greater will be the rotation, particularly with bluff-ended boats.

In common with the ship the frictional loss is the most important. Surface must be provided to act on the water to produce the necessary thrust, and yet not so great as to unduly increase friction; indeed, experiments show that beyond a certain surface ratio any increase is accompanied by a corresponding diminution of thrust.

The practice in the mercantile marine is to greatly increase the pitch angle near the hub. The natural effect, it seems to the writer, of so doing is detrimental to thrust, since it produces churning owing to the blades being in a greater fore and aft direction. It would be advisable to increase the diameter of the hub (which

has been done to a marked extent in a new type of propeller recently patented and fitted to some ships), and allow the pitch to maintain a more constant angle—in fact, it is probable that it would pay to maintain a constant pitch angle from tip to root.

From numerous analyses the writer has found that surface ratios of from ·35 to ·375 and pitch ratios of 1 give the most economical results. A few examples will serve to emphasise the point :—

	Cf.	I.H.P.	Area Coef.	Pitch Ratio.	Revs.	True Slip	Propeller Efficiency.
						%	%
1	·768	1304	·373	1·041	73·00	39·8	62·1
2	·755	1283	·373	1 000	73·00	33·0	64·5
3	·772	1522	·362	1·145	67·75	40·0	59·0
4	·81	2694	·425	1·000	66·5	38·0	60·5
5	·782	1608	·424	0 946	73·00	37·0	59·0

A study of this table will no doubt prove interesting. The ships are of a representative class, all working with their propellers well submerged. It will be noticed that the higher values of true slip are concurrent with relatively low values of propeller efficiency; this I have found to be generally the case.

No. 2 may be taken as an efficient type, though I can see no reason why an efficiency of 66 per cent. may not be attained.

As an illustration of what effect this would have on the coal bill, let us assume a 66 per cent. efficiency and apply it to a boat of 1,600 i.h.p., showing a propeller efficiency of 59 per cent. This amounts to an increase of 7 per cent. Seven per cent. of propeller horse-power represents a waste of 90 h.p., thus causing a waste of 1½ tons of coal per day to maintain the same speed, or on a year's steaming consisting of, say, 200 days, a total waste of 300 tons, in addition to which are the heavier engines and boilers, increased bunker space, and lessened hold capacity. The 90 h.p. means about 20 tons initially heavier engines and boilers; so that it will be seen considerable improvements could be introduced in this item alone, namely, lessened horse-power, lighter engines, decreased coal bill, increased cargo space and dead-weight capacity.

Summing up the efficiencies at 60 per cent. propeller, 80 per cent. engine and 95 per cent. hull, we arrive at a total propulsive efficiency of 46 per cent., which is the proportion of power absorbed in driving the ship to the amount indicated in the engines—or in other words 54 per cent. is wasted incidental to losses in engine and propeller.

Turning now to the effect of speed, it will be interesting to note the effect an increase has on the profit-earning capacity. For this purpose I have selected a typical tramp and worked out the various items affected.

The boat in question is 3,950 d.w. capacity, including bunkers—or actually 790 tons of bunkers and 3,160 tons of cargo, with a co-efficient of fineness of ·78. Her sea speed is 9 knots on 1,068 i.h.p.

Coal consumption per log was 19·6 tons per day, or 1·7 lbs. per i.h.p. per hour; total mileage for one voyage, 5,860 knots; this gives a total consumption of 525 tons. Allowing an additional half in reserve, this works out to a total bunker capacity of 760 tons for 27 days' steaming at 9 knots.

Increasing the speed to 11 knots per hour would require an i.h.p. of 1,580, thereby increasing initial weight of engines and boilers by 115 tons. The necessary bunkers would be 1,050 tons, thus requiring space for an additional 260 tons and lessening hold capacity by 11,700 c. ft., plus the additional space required by engines and boilers.

By making the speed 12 knots, a still more costly ship is the result; i.h.p. would be 2,550. Coal consumption per day 47·5 tons, or a total of 1,050 tons for 22·2 days' steaming, requiring a total capacity of 1,580 tons—that is an increase of 785 tons over the capacity at 9 knots and a loss of 35,000 cub. ft. of hold capacity, plus, as before, the increased length of engine and boiler space on account of the additional 1,482 i.h.p.

This involves machinery 330 tons heavier than that necessary at 9 knots. The figures tabulated are as follows, and are also shown graphically on diagram No. 1.

	9 Knots.	11 Knots.	12 Knots.
Steaming days ...	27	24·4	22·2
Indicated h.p. ...	1,068	1,580	2,550
Coal consumption per day ... (tons)	19·6	28·7	47·5
Bunker capacity (tons)	790	1,050	1,575
Increase of do. (tons)	—	260	785
Decrease of hold space (cub. ft.)	—	11,700	35,000
Weights of machinery (tons)	237	352	567

Another, and perhaps more graphic method of looking at the whole question of speed and force, is by considering both in combination and contrasting the number of tons of cargo carried, in a given period, per ton of coal consumption.

There are three distinct ships of identical dimensions but differing in coefficients of fineness, and consequently in dead-weight capacity. Each ship is run at three speeds—viz. 8, 10, and 12 knots respectively. Diagram No. 2 shows the indicated horse-power curves at these speeds.

As has already been remarked, the prime factor governing the type of boat is that the maximum dead-weight capacity must be obtained on the lightest weight of engines and hull; also the initial cost and working expenses must be kept at a minimum. Large cargo-carrying capacity is, as may be seen from the curves, most economically obtained by building full boats, cost per ton dead-weight being much less in this case than with a finer one; and, as is evident, the working expenses are kept low by running them at comparatively low speeds, but, at the same time, giving them sufficient power to reasonably expect a fairly steady head-way being maintained in heavy weather. Hence it is seen that there is every reason for the bluff, slow boats, running about 10 to 11 knots per hour, retaining the favour of shipowners.

The curves on diagram No. 3 only show the effect on bunkers; in order to obtain an idea as to the actual £ *s. d.* it would be necessary to take into account other items, such as oil, waste, loss of interest on money entailed by building a fine ship, etc. etc.

It must be understood that these figures only apply to steamers running on long voyages in the ordinary cargo-carrying trade, and must not in any case be applied to coasting vessels or those making comparatively short runs. In many instances increased speed could be attained by a comparatively slight increase of coal consumption—indeed, the number of additional voyages made per annum would more than compensate for the increased coal bill. But for long voyages it is beyond question that ships can only be run economically at higher speeds by introducing a finer model, consequently entailing greater first cost: thereby, in the vast majority of instances, any yearning after increase of speed is effectually killed.

The prime factor governing the speed and horse-power is the trade in which the vessels are to be employed. A speed which may return handsome profits in one case would be ruinous in another. Bearing in mind the extreme fluctuations of the freight market, too much attention cannot be paid in producing the most economical (not necessarily the cheapest) ships, so that in times of depression of freights the chances of running them at a profit may be greatly increased. Many steamers are now running at a loss which, by a reasonable amount of care and co-operation of shipbuilder and shipowner, could easily pay working expenses and still show a sum on the right side of the balance-sheet.

The writer trusts it is clearly understood that the figures given are only typical of tramps, and can in no way be applied to the higher classes of merchant and passenger ships, which depend for profit on a special type of cargo or carriage of passengers and mails.

H. BEAUMONT DONALDSON, M.N.E.C.Inst. E. & S.

High-Speed Engines.

Valves.

(Continued from Vol. VIII., page 414.)

THE high rate of reciprocation necessarily attendant on the action of the valves in this class of engine, for many reasons, practically precludes the use of slide-valves in almost any form, and piston-valves may be fairly stated to be a practical necessity.

Slide-valves may, of course, be relieved to some extent, this varying from half to three quarters the pressure area, according to the position of the valve on the ports; but it is impracticable to go very near a balance, both on account of the variation of the pressure area and the uncertainty of it, by reason of the face fits, which may be much or little. Also the variation of the pressure area necessarily produces the variable resistances to the working of the valves, which, in cases of the use of automatic expansion, are very undesirable on account of their effects on the governing arrangements. Therefore in spite of the fact that piston-valves will not work without some leakage, especially solid and without rings, they have still a balance of advantages which puts slide-valves out of the field altogether.

The chief difficulty arising from the use of piston-valves, is the relatively large clearance in the steam passages, and considerable care and ingenuity has to be exercised in design to keep this down to an unobjectionable point without losing area of thoroughfare. Port thoroughfares, however, of $\frac{1}{12}$ the cylinder bore may be had by careful arrangement, together with no more than about 7 per cent. clearances, and such do not greatly exceed those of most long-stroke engines. Such small clearances, however, demand some special considerations in the valve arrangements, which may affect the cost of other parts, especially in the case of compound engines.

Twelfths of the cylinder area for steam passages have become a sort of standard, arising out of locomotive practice, and for the purpose of conveying steam either from or to the valve are no doubt ample; but a travel of valve which will only give this full thoroughfare to the exhaust, will not provide, together with a proper steam distribution, a sufficient steam inlet to prevent undue throttling in a really high speed, or even in a moderately high-speed engine. The objects of locomotive proportions were rather to get the steam out of the cylinder than into it; for as the initial steam always was severely throttled (necessarily so), so far as the working of the steam was concerned, it mattered little whether the throttling took place at the valve or at the regulator. Further, on account of handling of the reversing motion the size and travel of the valves had to be kept down to a minimum, which was that which was sufficient for the exhaust. This cramping of size of valves, now that piston-valves, which are easy to manipulate, are in general use for high-speed work, is no longer necessary; and economy of steam pressure now demands the use of much longer travels and larger steam inlet thoroughfares in order that the boiler pressure may be more nearly maintained in the working cylinder. Admitting that twelfth parts, especially when of short length, are sufficient for passages, and considering that in stationary-engine work, where piston speeds of 700 to 800 feet per minute (together with long strokes) are common practice, fifteenths for steam inlet are necessary, it seems quite clear that for the proper maintenance of the initial pressure in engines working with rapid reciprocation, a full opening of the twelfth port for steam inlet (as a maximum) is required.

It goes without saying that the accomplishment of such actions entails con-

siderable departures from conventional proportions of bridges and exhaust-ports in cylinder faces or equivalents, as well as in sizes of eccentrics or means of working such valve travels as would be required. On the other hand, experience proves that there is no other way of preventing the initial-pressure losses which arise in working the steam in the class of engine under consideration, without increasing port clearance. Comparatively large diameter-valves are required in any case to get twelfth thoroughfares past or through them, and they cannot be much or anything increased in that direction, while the only other way of improving their efficiency is in the matter of travel. This does not increase the clearance at all, and it may be carried to the limit of a general convenience or to the point of necessity.

Seeing that the chief, or one of the chief, objects in the employment of high-speed engines is generally the grinding out of a maximum horse-power in a minimum space, engine efficiency becomes a point of primary importance, and any reasonable provision which will increase such efficiency is admissible, and it will pay for its cost.

The writer in no degree underrates the difficulties of obtaining and dealing generally with very long-valve travels, but advocates this way out of a difficulty which has to be faced, and as being much more economical in the long run, though more expensive in first cost than ordinary proportions. One of the difficulties in the way of ample and economical valve provision is the extra cost over the generally sparse arrangements used in commercial machinery of this class. The tendency to cut all round, even in the essentials of economy, prevents many builders from providing such things as they know quite well would be better than those which they put upon the market. The fault lies largely with the purchaser, who, size for size of cylinder, too often takes the lowest price, without taking any particular note of any difference in quality.

In regard to the merits of any particular form of valve-opening, seeing that the value of it is in the proportions of the area divided by the periphery, this fact leaves no doubt that short, wide openings are superior in effect to long, narrow slits, and that any area of the latter must be duly discounted to arrive at its correct value. This, again, points to the necessity of long-valve stroke. There are limitations to the latter, but where these are reached depends upon other than valve considerations. In regard to actual results obtained from proportions based on twelfth-part areas, reference may be made to Figs. 1, 2, 3 and 4. These are three views of a high-pressure cylinder and valve of a twin type compound engine, and the last fig., a steam diagram obtained in actual work under full load. The boiler pressure was 120 lbs. (135 lbs. absolute) the horse-power cut-off (automatic) up to half stroke, and the speed 275 revolutions per minute, with a 10-in. stroke of piston. The valve-openings were $\frac{1}{12}$-in. exhaust and $\frac{1}{18}$-in. steam. It is seen in Fig. 1 that the steam approaches the valve by a breeches pipe, which supplies each outer end of the valve separately. The cylinder ports are as short as it is possible to make them in the *side* of a cylinder, and it will be allowed that, for directness of supply, no better arrangement could be made, and therefore the conclusions may be taken as standard.

The indicator diagram (Fig. 4) was taken by a Crosby high-speed indicator in perfect condition, and coupled direct to the cylinder without any bends or pipes, the object being to get the absolute best figure possible. The drawing was pricked through the pencil lines of the original, and is as accurate as a copy could be made. The net result was that the steam in the cylinder at the commencement of the stroke had a pressure of 117 lbs. absolute, but that from that point to the cut-off point it ran down in an almost straight slope to 90 lbs. This means that the average pressure to half-stroke was $\frac{117+90}{2} = 103\frac{1}{2}$ lbs., or $13\frac{1}{2}$ lbs. loss to half stroke, or $6\frac{3}{4}$ lbs. for full stroke. The average pressure of the whole stroke was 30 lbs. The loss in engine efficiency was thus over 20 per cent. Of course, in no case could the whole of this be saved, but a considerable portion of it might have

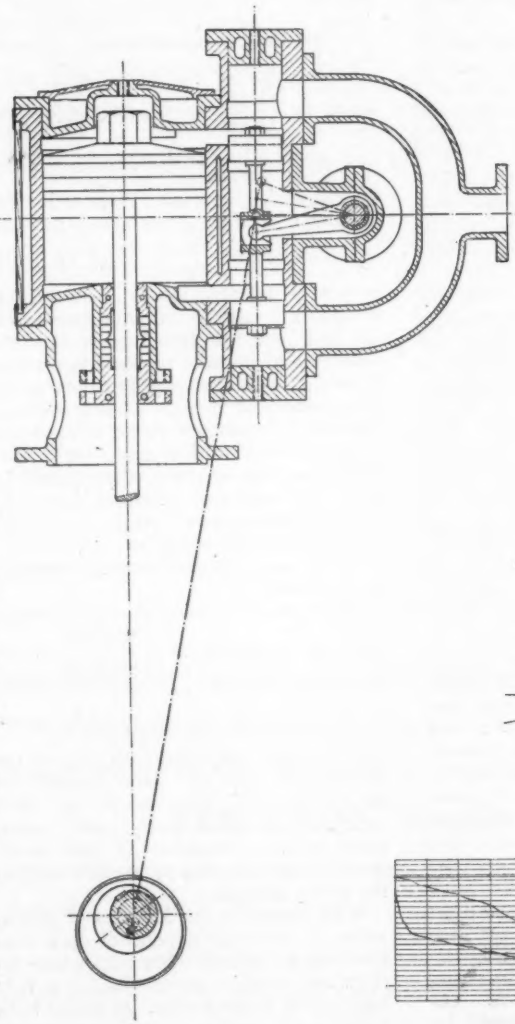


FIG. 1.

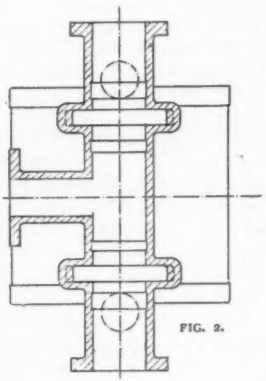


FIG. 2.

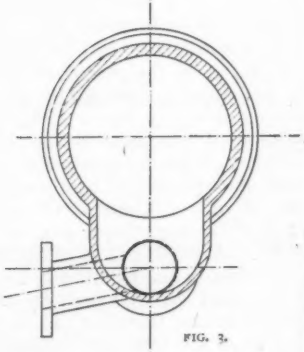


FIG. 3.

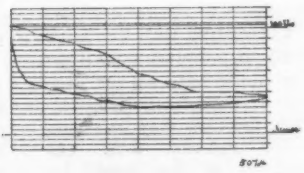


FIG. 4.

HIGH-SPEED ENGINES.

been with longer valve travel, without in any degree increasing the clearances, which in this case were $6\frac{1}{3}$ per cent., including those of the cylinder end, the latter being $\frac{1}{4}$-in., or $2\frac{1}{2}$ per cent.

The valve-motion in this case (which will be explained later) was as good as could possibly be got out of the travel, and the rate of motion at the cut-off point was about $\frac{6}{8\frac{1}{2}}$ of the maximum speed of the valve.

Useful conclusions may be drawn from such an example as this. The piston speed as seen is very moderate—only about 439 ft. per minute.

A point of some value in the foregoing demonstration is the steam velocity through the valve at the point when the crank had attained 45 degs. from the commencement of the stroke and which corresponded closely with the full steam opening of the valve, of $\frac{1}{18}$ of the cylinder area. The out-stroke at this point has proceeded about $\frac{1}{6}$ of the travel, and the piston speed is about $\frac{6}{8\frac{1}{2}}$ of the maximum velocity of the piston, which would be 720 ft. per min., so that $\frac{6}{8\frac{1}{2}}$ of 720 = piston speed at the time of maximum steam opening of the valve. This is about 508 ft. per min., which, multiplied by the proportion of the area of the cylinder = 18 would be 508 × 18 = 9144 ft. per min. or $152\frac{2}{3}$ ft. per sec. According to the diagram which, as has been before mentioned, as the best which could be obtained by the best ordinary means, there is a fall in pressure equal to 12 lbs. from the commencement of the stroke to the $\frac{1}{6}$ travel of piston which can only be due to the velocity of the steam and the nature of the valve opening. With regard to the value of the valve opening as compared with the value of the same area in a round or square pipe, seeing that these vary as the area in square inches divided by the circumference in inches, the case may be stated as follows:—The cylinder area was 186 sq. ins., and $\frac{1}{18}$ of that would be $10\frac{1}{3}$ sq. ins., say 10·33. The circumference of a circle having 10·33 ins. area would be 11·38 ins., therefore $\frac{10\cdot33}{11\cdot38}$ would be the relative value of a round aperture. The valve in question was 5 in. diameter, so that the run of edge of steam opening would be 5 ins. × 3·1416 × 2 = 31·416 ins. Therefore the area 10·33 ÷ 31·416 = $\frac{10\cdot33}{31\cdot416}$, which, compared with $\frac{10\cdot33}{11\cdot38}$, is the relative value of the valve area, which would be $\frac{11\cdot380}{31\cdot416}$ of that of a round pipe, or roughly $\frac{1}{2\cdot762}$, which of course explains a good deal. The same valve with twice as much opening would have a value, area for area, of $\frac{1}{1\cdot381}$, which of course is a very different result. The velocity through the valve in the latter case would be half that of the former, and the difference of pressure required to produce it only one fourth, or 3 lbs., thus saving a reduction of 9 lbs. This is striking. The writer is perfectly aware, as the result of many an all-round tussle with these things, that saying the opening should be such and such, and getting it, are quite two different matters. At the same time the direction in which to aim is clear, and that is a good deal towards obtaining improvement.

The value of an inch diameter circular hole as a passage is $\frac{\cdot7854 \text{ area}}{3\cdot1416 \text{ cir.}} = \cdot25$, while that of a 10 in. circular hole would be $\frac{78\cdot54}{31\cdot416} = 2\cdot5$, or ten times as good, area for area, requiring only $\frac{1}{100}$ of the pressure to pass the same quantity of fluid as the 1-in. hole, and so on. It is clear that a comparatively small betterment of the character of the steam opening makes a very great difference to the steam diagram.

With regard to the leakages of piston-valves, as these are dependent upon time they are no serious item, even where no rings are used, in engines having a very high rate of reciprocation. In actual work leakages are possibly less than in standing trials, as both the water of condensation and the lubricant will tend to prevent the passage of steam by leakage. In the writer's opinion, begotten of long experience, solid piston-valves (no rings) made

of a metal which is harder than the bores in which they work, and ground perfectly parallel and true (as well as the bores), leave little to be desired in the way of efficiency and serviceableness; and in an endeavour to eliminate all doubtful elements from a difficult problem, the writer prefers in all valves which are short enough and small enough to be dealt with in such manner, to do without rings. In the matter of steam tightness, the extra efficiency of ring-fitted valves when working is a very doubtful quantity, and the rings are a source of considerable risk from breaking and getting into the steam ports (sometimes with disastrous results); and they invariably wear hollows in the bores which, after a time, produce conditions much worse than any which are likely to arise out of the use of the solid plug. The writer has calipered one of the latter, 4-in. diameter, after four years' very hard work, and found the difference of diameters of the piston and bore to be less than $\frac{1}{1000}$ of an inch more than the sizes at which they started. These were a good job at the time they were new (that being an absolutely necessary condition for valves of this class), and, moreover, were polished, both bore and valve, before they commenced work, this also being an essential point. The wear was practically nothing. The form of the bore was quite perfect, and a new plug, costing very little, was all that was necessary to make a new job when the old one got too easy. This is a great advantage.

Where long bores and piston-valves are necessary, as in some single-acting engines, the case is different. There are difficulties of making dead-true parallel bores, and difficulties of making certain that the desired conditions are realised, so that in such circumstances the use of rings is practically imperative; so also is the building up of the length of the valves in sections for securing some lateral flexibility. Vertical position in working may be said to be a necessary feature for ensuring the correct wear of any piston-valve.

J. H. DALES, A.M.Inst.C.E.

(To be continued.)

It has been represented to us from time to time by numerous readers and advertisers that the title at present borne by this Journal—viz.

FEILDEN'S MAGAZINE,

does not adequately describe its position in the literature of technology, nor does it indicate the thoroughly technical character of its contents.

It has been decided therefore that, commencing with the JANUARY Number of 1904, the title will be altered to

THE ENGINEERING REVIEW.

Modern Crane Construction.*

(Continued from Vol. VIII., page 409.)

Overhead Cranes.

We will now consider the many varieties of overhead cranes, from the simple hand-power type, lifting 2 or 3 tons, to the latest electric-driven type, dealing with loads of 75 tons.

An overhead crane is one that works on a gantry, or upon overhead rails fixed inside a building.

For cranes up to 3 tons capacity, two pitch-pine beams, firmly trussed, frequently form the span of the crane. These beams are securely bolted to the end carriages, and have transverse travelling rails laid on the top. The end carriages are prepared to receive two longitudinal double-flanged travelling wheels and travelling gear. The crab is mounted on two pairs of double-flanged travelling-wheels, which run on the transverse rails. Generally all motions are worked from the crab, but sometimes the longitudinal travel is worked by means of a handle and spur gearing at the carriage ends. Single-purchase lifting motion is given by spur gearing from the handle-shaft, on which a sliding pinion provides for double purchase motion. The transverse or cross-travel is also operated by spur gearing and a sliding pinion on a handle-shaft, independent of the hoisting-motion handle-shaft. If the longitudinal motion is worked from the crab, the gearing is so arranged that both ends of the crane move together.

A ratchet and pawl are fitted to the second-motion shaft, to prevent the load from running back whilst the crab is being travelled or the gear changed, and a strong brake is also fixed to the same shaft. For cranes above 5 tons capacity, or where the span is great, rolled-steel joists or built-up girders take the place of pitch-pine beams for the span.

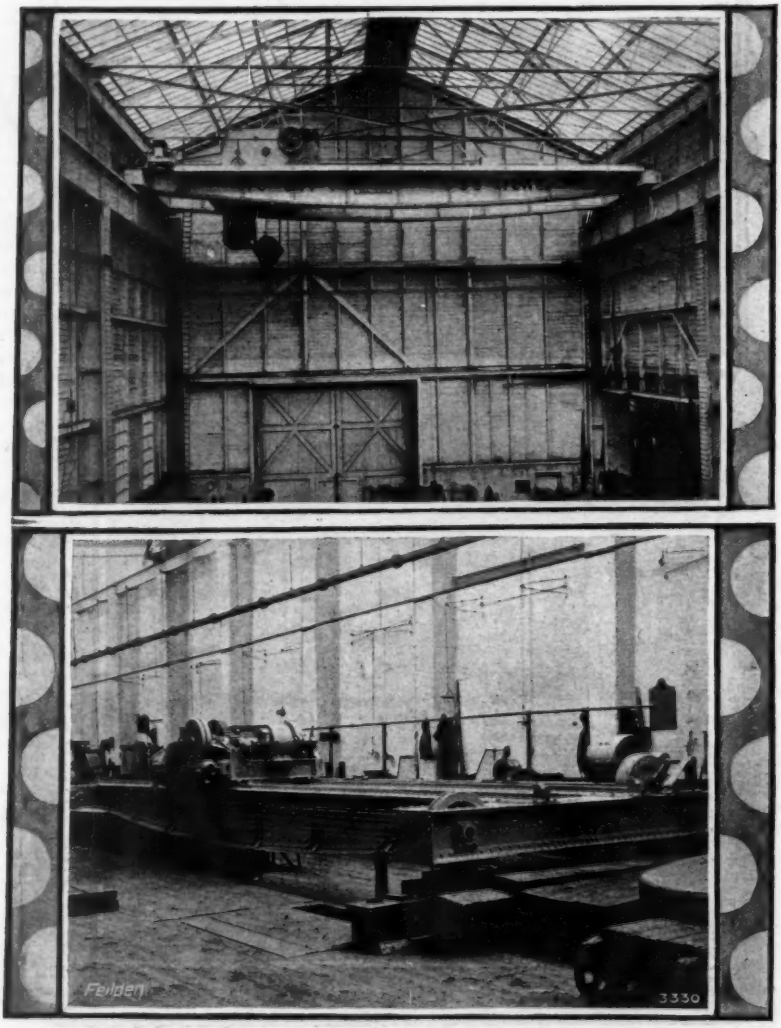
For some purposes it is inconvenient for the operator to have to ascend a ladder to the crane before he can use it, and sometimes one man may require to lift a light load and to be on the ground to direct its movements. To provide for such cases, overhead cranes are often fitted with chain-wheels and chains, or rope-wheels and ropes, to the ground level to take the place of the handles.

The photo on p. 400 (Vol. 8) is of a 10-ton overhead traveller, made by Messrs. Rushworth Bros., of Colne, all motions of which are worked from the ground by means of chains. The span of the crane is 38 ft., and the cross-beams are composed of two rolled-steel joists, 18 ins. by 7 ins. section.

Power can be applied to an overhead travelling crane by means of an endless rope from a countershaft along the yard or shop where the crane has to work. One of the end carriages is made in box form, and the rope pulleys are placed on the end. There are three of these pulleys in addition to those required as guide pulleys, and each one is fitted on a short shaft, coupled to a double male and female friction cone. The friction cones have cast on to them bevel gearing, and the frictions are operated by means of hand-levers. The longitudinal travel is operated by means of the spur gearing as described in the hand-power traveller. The hoisting motion of the crab also takes its power from the frictions and a round shaft with sunk keyway carried across the full span, supported by tumblers in the centre, and pedestal on the other end of crane. A bevel pinion, working in a bearing attached to the crab, and sliding along the shaft with the crab, transmits power by means of an upright shaft and worm-gear on the first-motion shaft. Thus, on whatever portion of the span the crab may be when the friction is put into action, the first-motion shaft is revolved and the load is lifted or lowered by means of the spur gearing. The cross-traverse is also operated by means of a square shaft and bevel gearing through spur wheels to the axles of the crab travelling wheels. All

* Note.—Figures 11, 12, 16, and 17 appeared in the previous instalment of the article.

MODERN CRANE CONSTRUCTION: FIGS. 10 AND 11.



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14

MODERN CRANE CONSTRUCTION: FIGS. 18 AND 14.

the motions are under control from a platform on the end carriage, or from a cage suspended under the crane. The latter method allows the operator a better view of his work generally.

Where the head room is so limited as to prohibit the use of a crab, the whole of the gearing is fixed on one of the end carriages. A small trolley on four tram-wheels is then used to traverse the span, in order to have winding rope or chain exactly over the load, and is operated from the end by means of a racking motion.

Fig. 11 (p. 406, Vol. 8) illustrates a 7½-ton rope-driven travelling crane, made by Messrs. Rushworth Bros. This traveller has a span of 22 ft., and was built to travel over an iron foundry 200 ft. long. The cross-beams are of pitch pine, suitably trussed, and all motions are worked from the top of one of the end carriages.

Steam engines may be direct coupled to overhead cranes, forming the type of self-contained overhead power-driven crane generally used, but oil engines have recently been applied in this manner with good results.

The transverse beams are of the built-up girder type, having steel rails, and are prepared to receive the crab, engines, boiler, and water-tank, or the crab, oil engines, and auxiliary appliances.

Occasionally such a crane as this has to be worked inside a building, where the head room is limited, and it is necesssry then to place the boiler and engines on a platform fixed on the underside and between the two transverse girders, from which the attendant has control over all motions.

Fig. 12 (p. 403, Vol. 8) is from a photograph of one of the largest self-contained steam-driven overhead cranes ever constructed. This crane was built by Mr. Thomas Smith, of Rodley, near Leeds, for a firm at Newcastle-on-Tyne. It has motions for hoisting, lowering, and travelling, both longitudinally and transversely. The span is 50 ft., and the crane has been tested with a load of 75 tons. The hoisting motion is treble purchase, with three lifting speeds.

The steel wire rope is 6 ins. in circumference, running in four plies in top and bottom blocks, the latter being provided with a special swivel having antifriction rollers, allowing the hook to turn easily with the full load suspended. The transverse beams and end carriages are of box-girder section, with steel axles and steel-tyred travelling wheels. The boiler and water-tank are fixed on the box casting of crab. The engines have diagonal cylinders 9½ ins. diameter with 14 ins. stroke, working with steam at 80 lbs. pressure. All steam pipes are of copper, and the chimney is hinged for passing under roof principals where they are low.

It will be seen from the illustration that the crab, engines, and boiler are compactly arranged, and occupy very little head room.

Such a crane is just the sort of machine that will rapidly and economically perform the work necessary in shops where heavy weights have continually to be moved from one position to another.

Electric Overhead Cranes.

Electric overhead travelling cranes have made rapid progress during the last eight years. The modern electric traveller avoids the waste of power inseparable from machines driven by the means already described, as immediately active work is suspended the motors are stopped and the supply of current ceases.

When electricity was first utilised as the motive power for overhead cranes, one motor running constantly in one direction worked all the motions. The power was transmitted, either by spur gearing or a belt, to a shaft fixed in the end carriage, and from which all motions were worked. Cranes embodying this arrangement are still being made in large numbers, as the initial cost is much below that of three-motor cranes, whilst the working efficiency is almost equal. The constant speed of the motor is varied by the gear and is not dependent on the load, and reversing is quickly effected.

Fig. 13 illustrates a 10-ton overhead electric traveller made by Messrs. Rushworth Bros., of Colne, the span being 43 ft. 6 ins. The crane is of the one-motor type, actuated by a completely

enclosed compound-wound motor. The motor is mounted on one of the end carriages, and picks up current by means of a "slipper" from the live wire, which is carried along the runner edges on insulators. Power is transmitted from the motor to a pulley on the end of the main shaft by means of a leather belt.

The type of electric traveller which is now considered to be the most efficient is that in which each motion is fitted with its own motor. Each motor starts from rest, therefore starting gradually and allowing small and delicate motions to be carried out easily. This easy starting, together with the complete and independent control the operator has over each motion, allows a higher average speed to be obtained from the three-motor crane.

Fig. 14 is an illustration of a three-motor crane built by Messrs. Joseph Adamson & Co., of Hyde, for the brass foundry of Messrs. Armstrong, Whitworth & Co. The crane mentioned is fitted with enclosed motors of the series type, fitted with reversing controllers, and calculated to run at a speed of about 600 revolutions per minute. The first reduction gearing is enclosed in cast-iron cases to exclude dust and to retain the lubricant. This reduces the wear and tear of gearing to an unappreciable amount. The motor on the side of the crab is fitted with an automatic brake, so that if the current is cut off for any reason the load does not run down, but remains suspended. This motor drives the hoisting motion, the first reduction being through worm gearing, as the makers assert that when carefully constructed this gives efficiency almost as high as that obtained from spur gearing. The motor for cross travelling is also mounted on the crab, the longitudinal travelling motor being fixed on the side of cross-girder, near the end carriage.

Fig. 15 shows a 20-ton crane, by the same makers.

The longitudinal travelling motor in this crane is secured to the outside of cross-girder, in the centre of the span, and works the end travelling wheels by means of pinion and spur-wheel. The cage from which the attendant controls all motions is slung under the girders at one end, the top part of the cage framework being visible in the illustration.

Fig. 16 (p. 402, Vol. 8) is a 20-ton overhead traveller by Mr. Thos. Smith, of Rodley, near Leeds. The motors are all of the enclosed type, and all motions are worked through spur gearing. Since few of these large cranes are utilised all the time for lifting their maximum loads, it has been found advantageous to use a fourth motor, working an auxiliary hoisting drum for small loads, as in the crane shown in this illustration. The usual speed for the full load is about $4\frac{1}{2}$ ft. per minute, whilst the auxiliary barrels lift at say 16 ft. per minute, no time being lost in any change of gear. A good view is given of the reversing controllers, and of the cage for the attendant.

Fig. 17 gives a view of the same crane, looking down to the end of the crab, and showing the motors, winding drums, and snatch-blocks.

Fig. 18 is from a photo of a 30-ton overhead electric traveller erected by Messrs. Joseph Adamson & Co., of Hyde, for the Wallsend Slipway and Engineering Co. The cross-girders and end carriages are of the box-girder design, and the crab sides are of steel. An important detail is that the motor-shaft and first-motion pinion are made of nickel steel, either in one piece or united by solid flange couplings, as on the propeller-shaft of a steamship, the shaft being swaged down from a forging of the size of the pinion or coupling blank. This adds to expense, since the swaging, the higher cost of nickel steel, and the fact that it cannot be turned nor the teeth cut so readily as the ordinary mild carbon steel, are cumulative items; but keys are avoided, with the risk of their working loose.

This crane has an auxiliary barrel for light loads, actuated by a fourth motor, and the cage, instead of being slung as a fixture at the end carriage, is suspended from and travels with the crab. This enables the operator to be as near as possible to the work he is lifting.

The motors are of the series-wound type throughout, and enable the crane to work loads and to travel at higher speeds without change of gear.

The winding barrels are grooved from each end, so as to give a true vertical lift. The crane hook turns on a ring of ball bearings between steel washers, thus facilitating the turning of the full load without twisting the ropes. The rope runs over a compensating pulley, which has its bearings in a stiff cross-beam, bolted across the crab sides. All motions are worked from independent reversing switches placed in the cage, and all may be in action at the same time if desired, independently of each other and in either direction.

This crane possesses additional interest from the fact that the shop is very lofty and the lifting speed very high; so high, in fact, that nearly 40 h.p. is absorbed by the hoisting motion alone under full load, an amount of energy which it would be difficult to provide with any other type of crane.

Another type of electric crane is built on the lines of an independent pillar crane, with projecting jib, and mounted on a steel trolley structure spanning the rails over which it has to work. This structure has four steel legs, well braced together, the bracing on both sides being sufficiently above the track to allow a loaded wagon to pass under. A steel platform is riveted on the top, to take the whole superstructure and external wheel for revolving motion.

The motor for the travelling motion is mounted on a stay to one pair of the legs nearest the track, and transmits the power to the travelling wheels by means of spur and bevel gearing. In order that both sides shall travel at the same time and speed, a vertical shaft is carried up the legs and the motion is carried through bevel gearing to a cross-shaft, thence to a vertical shaft on the other side of structure. The jib is of steel, latticed with steel strips and secured to a steel framework at the back of the crab.

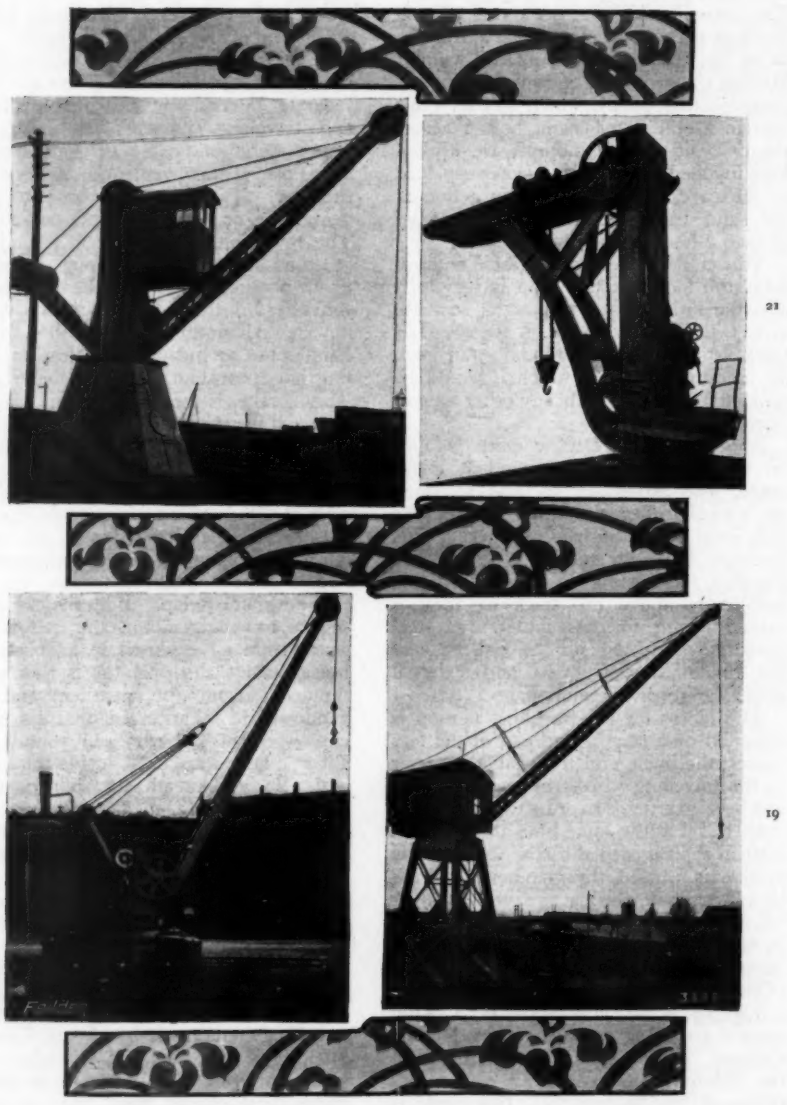
Fig. 19 is an illustration of a 3-ton electric travelling crane made by Messrs. Cowans, Sheldon & Co., of Carlisle, for the North-Eastern Railway Company's docks at Middlesbrough. The photo is from one of seventeen travellers supplied for the docks.

The radius is a fixed one of 44 ft. 9 ins., and the height from the quay level to the centre of the jib-top pin is 60 ft. The crane body revolves on live steel rollers on the top of the pedestal framing. The pedestal framing is of simple construction, strongly braced and tied. There are three separate motors for hoisting, revolving, and travelling, current being supplied from underground cables through coupling boxes placed at convenient distances along the quay. The crane lifts 3 tons at 150 ft. per minute, or $1\frac{1}{2}$ tons at 225 ft. per minute. The revolving speed is 400 ft. per minute at the hook, the travelling speed is 40 ft. per minute, and as the motors are series-wound, these speeds can be varied at will. All motions are controlled by one handle, the attendant being free to have one hand constantly on the brake lever. This brake is held up by a solenoid arranged in series with the motor, so that if the current fails the brake goes on automatically. In addition to this the attendant can apply the brake mechanically at will. All the gearing is machine cut, enclosed and fitted with oil baths. The hoisting drum is turned and grooved, and is large enough to receive the wire rope without overlap. With the exception of the travelling motor, the motors and gearing are all enclosed in a substantial house, where the operator is thoroughly protected from the weather, and the windows are so arranged that he has a clear view of his work all round him. Electric lamps are fixed inside the house, and also underneath the jib for night work.

Hydraulic power is also used for the operation of cranes, generally similar to the last one described, the power being conveyed through flexible hose coupled to the supply valves, arranged at convenient distances along the pressure main, when the crane is required to travel from point to point.

Fig. 20 is an illustration of a hydraulic travelling crane made by Messrs. Cowans, Sheldon & Co., Ltd., of Carlisle. For some purposes it is useful to be able to move these cranes from place to place independently of the rails, and the crane shown in illustration is thus adapted.

The framing is of steel, and carried on



MODERN CRANE CONSTRUCTION: FIGS. 8, 19, 20, 21.

four flangeless wheels, kept wide on the tread, to travel along the quay walls or roadway. The hoisting cylinder and rams are in the main upright framing, and the two revolving cylinders are arranged, one on each side vertically, as shown. The power is conveyed through cocks coupling up to telescopic pipes fitted to the crane. The jib is secured to the top of the frame-work by bridle rods, and has a balance-weight fixed on the other side. The attendant's cabin is placed well up, so that he has a clear view of the work. This type of crane is largely used for loading and discharging of ships and coaling purposes.

Foundry and Other Cranes.

There are several minor types of cranes, outside the range of this article, which, however, would not be complete without some reference to the type of crane generally in use in foundries, forges, and steel works. The space available in such works is generally valuable, so that a crane has to be adopted taking up as little room as necessary, together with as wide a range of usefulness as possible, The body of such a crane has a footstep for fitting in the floor, and a preparation for receiving the body top pin, working in a bearing fixed on the ceiling joists. This enables the crane to be revolved, so that it can be used all the way round itself. The body is composed of two rolled steel joists, fitted with the necessary bearings for the gearing. The jib is constructed of steel plates and angles or steel joists securely bolted or riveted to the uprights at top, and at right angles to the upright. The jib is strengthened by means of steel plates riveted to the front side of the uprights and to the underside of the jib. In order to adjust the radius a small trolley traverses the joists forming the jib, and to this trolley the ends of the racking chain are attached. The trolley can be moved to any part of the jib where the load is required to be lifted. The end of the winding chain is secured to the end of the jib, the block and hook being suspended between the two pairs of travelling wheels of the trolley.

Fig. 21 is from the photo of a steam foundry crane made by Mr. Thos. Smith, of Rodley, near Leeds. A crane of this construction is useful where quick handling is necessary, and it hoists, lowers, racks the load in and out, and revolves by steam power, but is fitted so as to be worked by hand-power if required.

A steam Goliath crane is an overhead crane, but has its own supports instead of timber uprights and runners, as in the ordinary overhead traveller. The supports are constructed of steel, and designed to span two or three lines of metals. Hand, steam, or electric power may be utilised. The whole structure travels bodily to the place where it is required, a method of application which saves much room, and removes the necessity for the usual cumbersome upright timbers and runners.

Messrs. Cowans, Sheldon & Co., Ltd., of Carlisle, erected some little time ago on the Clyde a large steam wharf crane, which is a good specimen of modern crane-building. This crane lifts 150 tons at a radius of 65 ft. Each motion has a separate pair of engines, and a third pair is utilised to drive an auxiliary lift up to 20 tons.

The jib is composed of two steel tubes, all joints being turned and butted, and the whole being well braced together. The crane weighs close on 400 tons.

Much more could be added on the subject to which this article has been devoted, and in which the author has endeavoured to set forth the leading features of typical examples of modern crane construction.

GEO. W. RUSHWORTH, A.M.I.Mech.E.

The Physics of the Steam Boiler.

Two notable books* have lately appeared, dealing with boilers and their construction, but though both works, judging from their titles, would appear to deal with boiler construction independent of any particular type, as a matter of fact the first-named volume barely touches cylindrical boiler construction, and the interest attaching to both works centres round the vexed question of "watertube boilers." The subject is dealt with by two very different men—different in training, different in the work they have done, and different in nationality. Mr. Rowan and his father have for years and years been interested in the introduction of the watertube boiler, and were among the early pioneers in this class of work. M. Bertin, the chief constructor of the French navy, has had exceptional advantages of studying closely the introduction of the watertube boiler into the French navy, which was the first to adopt that type of boiler on an extensive scale. M. Bertin is a keen observer, and states his case with a clearness and fairness which is not often met with. Further, on all matters concerning the latest French vessels and their trials, he has access to the most recent and most accurate information; and for this reason, if for no other, the present new edition of his work will be read with interest by engineers in general and by naval engineers in particular. Mr. Leslie S. Robertson translated and edited the English edition of M. Bertin's first French edition, and we are informed that he proposes shortly to bring out an English translation of the present French edition. It may therefore be simpler if we deal with the volumes under consideration separately, touching briefly on the more salient points of each.

* *The Practical Physics of the Modern Steam Boiler.* By Fred. J. Rowan, A.M.I.C.E., etc. London: P. S. King & Son; New York: D. van Nostrand. 21*s.* net.

Chaudières Marines. By L. E. Bertin, Directeur des Constructions Navales. Second Edition. Paris: E. Bernard et Cie. 25 francs.

Mr. Rowan has evidently had his work in preparation for a number of years, and it is the result of an immense amount of close study and labour. The author has tried to gather together in this work all the best results, descriptions and illustrations relating to water-tube boilers and the subjects cognate thereto. The subject-matter must not, therefore, be expected to be original, though it is none the less valuable for this; on the contrary, Mr. Rowan's object has been to select the best published information and then to put it into a concise and easily accessible form for reference, commenting on the results obtained and their influences on design. He particularly repudiates any claim to originality, and has endeavoured to acknowledge all the sources from which his information has been culled.

The book has suffered somewhat from being too long on the stocks; *i.e.* a certain portion—and that the major portion of the book—appears to have been written some time ago—in fact, about 1898. The author then seems to have concentrated his energies on the historical side of the subject and the research connected therewith, without finally revising the earlier portions and bringing them up to date. The result is that we find that particulars of the trials carried out by the Boiler Commission appointed by the Admiralty are conspicuous by their absence in the body of the book, and are only very briefly referred to in the author's preface.

Among the sources of information from which Mr. Rowan has largely drawn are the writings of Prof. Thurston, of Cornell University, who has added an "Introductory Note" to Mr. Rowan's book. Prof. Thurston thinks that the title of Mr. Rowan's book is well and aptly chosen, and defines "admirably his field of exposition." He says: "The enormous aggregate of information from authoritative sources here collected is accompanied by much instructive comment and many helpful suggestions, and

the book will be found a mine of valuable and solid learning in this field. The facts gathered together and the principles illustrated and elaborated, the numerous drawings of the most important inventions and constructions, and the systematic presentation of all should prove useful to every class of reader."

Prof. Thurston, in the closing paragraph of this preface, refers to a side of the question which theorists and others are far too apt to overlook; and that is, that all engineering problems must more or less come down to the question of pounds, shillings and pence. Ideal designs are all very nice, and statements of conditions to be fulfilled are very interesting, and comparative studies as to how the various types of boilers fulfil the conditions laid down may have a certain academic interest; but the cost of construction, cost of repairs and maintenance, economy of fuel, and other cognate matters, are questions of paramount importance to the every-day practical engineer who is in charge of a line of steamers, or who has to run a large generating station.

This side of the boiler problem is one which is often, nay usually, neglected in text-books, for the simple reason that it is one of the hardest questions upon which it is possible to obtain reliable and authentic information. Mr. Rowan has not devoted much attention to this side of the problem, and it is to be hoped that in any subsequent edition the financial question will receive the attention it deserves. Prof. Thurston says: "The engineer is thus necessarily, if successful, a financier of high rank, and his success must always be ultimately gauged by a monetary standard. There is always a certain proportion and size of boiler of any one class and type which affords a solution of this problem of the golden mean."

The work itself occupies some 600 pages with over 300 illustrations, and is divided into nine chapters, dealing, among other questions, with "Combustion," "Transmission of Heat," "Circulation of Water," "Influence of Temperature on Metals," "Corrosion and Incrustation," "Tests and Trials," and one chapter is devoted to the History of the Water-tube Boiler. Space precludes us from dealing with the chapters in detail, but suffice it to say that under each heading Mr. Rowan has attempted to collect the best information procurable on the various subjects dealt with. The classical experiments by well-known physicists and engineers, whose names are too numerous to mention, are all given, and the results arrived at are carefully compared and their bearing on design and construction discussed. The whole interest of the work centres round the water-tube boiler, and the cylindrical boiler is hardly touched upon at all. Further, the whole subject is viewed, as one would have expected from a Clyde man, in the light of "marine work." This is hardly a disadvantage, as the conditions obtaining afloat are far more arduous than those obtaining on land, and therefore all details have to be studied with a care and a forethought not always necessary in land work, where weight and space are not such important factors in the problem. The chapter on the historical part of the question is replete with references and illustrations, and the work and research involved must have been prodigious; but, it is difficult to ascertain which of the various types have proved commercially and practically most successful, and which have failed, and from what cause.

It appears to us a pity that the publishers have tried to cram so much subject-matter into one volume; it has entailed unduly compressing the work, the clearness and distinctness have consequently suffered, and in some places seriously. It would have facilitated reference if the work had been divided into more headings, and these printed in bolder type and numbered where possible; and also if the Index had been more complete. In works of reference, such as this is, facility of reference is an all-important question.

Despite these few oversights Mr. Rowan must be congratulated on the successful completion of a work which must have occupied him many years in preparation. Engineering literature is distinctly richer to-day by the completion of a book which must take a foremost place amongst the

many works already existing on the modern steam boiler.

M. Bertin's new edition covers practically the same ground as his first edition, to the English translation of which a preface was written by Sir William H. White. M. Bertin has used the interim to revise and complete the information contained in the first edition and bring it up to date. There is little or nothing that calls for remark in the three opening chapters, except that one or two figures have been revised and some of the tables have been enlarged. Chap. IV. on "Production of Heat from Coal" has been added to, where the use of economisers has rendered revision necessary. The extended use of Howden's system of forced draught has received the notice it deserves, and the most recent applications of this system are given. The subject of mechanical stokers afloat has received further consideration; and M. Bertin gives instances where the chain-grate stoker and the under-fed stoker have been tried with varying success. As a rule hand stoking is reverted to in all cases, and mechanical stoking, with all its apparent advantages, cannot yet be said to have proved itself suitable for marine work, in spite of all the attempts that have been made to introduce it. M. Bertin gives instances where pulverised coal has been used on shore, but says that it has not been tried afloat as far as he is aware.

The principal addition to the second editions are in the chapters on Liquid Fuel and Small-Tube Boilers. The chapter on liquid fuel has been extensively revised and enlarged; and, as this system appears to have been used with greater success in foreign navies than it has hitherto realised in our own navy, the data given by M. Bertin will be received with interest. He deals first with the different sorts of petroleum used, with their chemical composition, and then with their different calorific values and properties. After this he passes on to describe the better known classes and types of burners that have been used; and here a lot of new information is added, though strictly speaking some of the burners quoted are more suitable for burning petrol than the heavier oils. The burners dealt with in the second edition that do not figure in the first edition are those of Niclausse, Escher - Wiss, Koerting, Cuniberti, Urquhart, Standart, Choukoff, Daniline, Nobel, Lenz, Holden, Orde, Leduc, and others. Then M. Bertin passes on to discuss the question of the efficiency of liquid fuel, of its advantages and disadvantages, of its future use, of its efficiency as compared with coal; and he gives an account of many of the trials that have been made in the French navy and elsewhere, together with the results obtained on these trials.

Chapter VI., on the "Production of Heat," has received considerable additions, especially in those portions dealing with the heat produced by the combustion of petroleum. The results of M. Ser's experiments on the speed of water and the better absorption of the intense heat of combustion are also referred to in this chapter, as are those by Watt and Niclausse. The paragraph dealing with laggings has been enlarged by the addition of some interesting experiments made by the Grand Trunk Railway on mica boiler covering. Chapter VIII., on "Cylindrical Boilers," has received one important improvement by the addition of a paragraph on the effect upon boiler design of the use of high tensile steels.

Next in importance to the additions made to the chapter on liquid fuel come those made to the chapter on tubulous boilers. Here M. Bertin has added many new figures, some relating to improvements effected in well-known types of boilers, and some illustrating types of boilers not touched upon at all in the first edition. The results obtained by the Babcock & Wilcox boiler, which were decidedly meagre in the first edition, have been brought more up to date in the present volume, and the particulars of numerous trials are given. A description of the 'Climax" boiler is added, though this type of boiler does not appear to have been tried afloat. A good deal of supplementary information is also added in reference to the Niclausse boiler and the recent results obtained. The Normand-Sigaudy boiler, which consists practically

of two Normand boilers placed back to back with common upper and lower drums, has been tried lately in several large boats in the French navy, and M. Bertin has wisely added somewhat extensively to the information given in his first edition about this class of boiler, as also to the information on the general extended use of the small tube boilers.

The information on the Thornycroft boiler is also fully revised, and full descriptions are added of the new Thornycroft boiler and the Thornycroft-Schulz boiler. Among the new boilers described in the second edition are the Weir, the White-Forster, the Mumford, the Ansaldo, the Turgan, the Borrot, the Brillié and others.

The closing chapters on auxiliary fittings have also been slightly revised, and many of the obvious gaps existing in the first edition have been filled in.

The interest of the new edition centres round the fresh information added on Liquid Fuel and on the historical part of the work. The latter is by no means so full as that given by Mr. Rowan, no patents, etc., are quoted, but, on the other hand, M. Bertin deals almost exclusively with boilers that have been actually tried on a practical scale at sea, and gives some valuable information as to the reasons of the various successes and failures.

M. Bertin's style is always clear and explicit, his sources of information, official and otherwise, are second to none when dealing with water-tube boilers; and, though in its present form the book is more or less limited to those conversant with the French language, the forthcoming English edition will place it within the reach of all students of the water-tube boiler.

L. S. R.

It has been represented to us from time to time by numerous readers and advertisers that the title at present borne by this Journal—viz.

FEILDEN'S MAGAZINE,

does not adequately describe its position in the literature of technology, nor does it indicate the thoroughly technical character of its contents.

It has been decided therefore that, commencing with the JANUARY Number of 1904, the title will be altered to

THE ENGINEERING REVIEW.

Conditions Governing the Production of Steam Metal Alloys.

UNIVERSAL foundry experience testifies to the fact that no one particular mixture of metal will under all conditions always yield uniformly good results. A long period of success may follow the adoption of a certain composition, but almost inevitably a time comes when mechanical test values begin to fall and occasional castings are rejected on steam or water trial. This is especially the case with the modern type of high-pressure steam or hydraulic fittings, failure may follow a run of extremely successful castings; or it may be that interspersed among the good castings are several rejections due to "sweating." These conditions are familiar to all engineers experienced in testing hydraulic or steam fittings; and very naturally the question arises, if a certain alloy produces good results one time why may it not be relied on to yield good results at all times. It is therefore proposed to examine some of the conditions which govern the productions of these alloys, basing this examination on the controlling conditions of the foundry rather than on any special type of composition. The constitution of the alloy is of course important, but viewed from the one point of resisting the penetrating action of liquids or steam under pressure, no one of the usual mixtures employed for gun metal is superior to another. Under certain conditions castings of an expensive type of gun metal may "sweat" at comparatively low pressures, whilst on the other hand castings of a cheap type may remain perfectly tight at pressures of over 1000 lbs. per sq. in. The tenacity of the alloys is however of moment, in that a tenacious one is enabled to resist deformation or even rupture when under pressure. Whilst it is not intended to discuss the composition of steam metal alloys, it may be of interest to indicate briefly the usual types employed for this class of work, confining the mixtures given to those known as "gun metal."

	1.	2.	3.	4.	5.	6.
Copper ...	88%	86%	87%	80%	80%	70%
Tin	10	10	8	6	5	4
Zinc... ...	2	4	5	8	10	4
Lead ...	—	—	—	6	5	4
Merchant scrap ...	—	—	—	—	—	18

These compositions are given in relative order of cost, which decreases as the expensive metals copper and tin are replaced by zinc or lead. The first three vary slightly and are types of high-class steam metal, No. 1 representing the Admiralty specification for steam fittings. No. 6 represents a fairly cheap type of gun metal, the scrap being of course merchant and not foundry scrap. Higher contents of zinc are used for low pressure fittings, indeed these latter alloys often approach the "yellow" type of brasses.

In the case of a mixture which in the past has given good results, suddenly producing castings which meet with rejection on steam or water trial, the remedy will be found not in an erratic change of composition or the adoption of a special flux but in a thorough diagnosis of the conditions under which the casting was made. Of these determining conditions the following are the most important, and apply to any copper-tin alloy irrespective of its composition:

1. The purity of the metals employed.
2. The initial casting temperature of the alloy.
3. The preparation of the mould including the method of gating, the size of the gate, the rate of pouring, and the disposition of chaplets or studs.
4. The method of melting, including the length of time to which the alloy after becoming molten has remained in the furnace.
5. The presence of oxide, dross, or mechanically held foreign matter, such as cinder, sand, and so forth.

6. The presence of blow-holes, cold shuts, etc.
7. Shrinkage cracks or unequal shrinkage.

With the exception of 1 and 2, the foregoing conditions are such as may be held, by the exercise of ordinary foundry care, in perfect control. Unequal shrinkage (7) may be due to the method of gating, the casting temperature, or the design of the pattern, the last being chiefly responsible for failures due to shrinkage owing to that canon of foundry faith—gradual change in the thickness of the section—being departed from. A familiar example of abrupt change in the thickness of the section is found in the junction of an ordinary valve body with the flange, as in Fig. 1. Hydraulic castings are especially guilty in this respect, and it is no uncommon thing to see flanges having a thickness out of all proportion to that of the body. Hence, unequal shrinkage is bound to occur, and the weakest part of such a casting will be the junction as indicated by the arrow on Fig. 1. In actual practice such junctions are, of course, filleted, but in the majority of cases this fillet is of so insignificant a character as to have little or no bearing on our present consideration of unequal shrinkage. A valve body, such as the foregoing, in which the metal of the flange bears a ratio to that of the body of 4 to 1, is very likely to leak at the junction when tested by water pressure at 1000 lbs. per sq. in. Contraction in the case of the light body will be complete long before that of the flange, and the junction is bound to be more or less strained. Similar conditions prevail if heavy bosses are cast on the bodies; the immediate junction of boss and body offers a favourable locality for leakage when under pressure. Under certain conditions of casting temperature the junction of the boss and body may be drawn into a series of fine holes round the circumference, any one of which will readily admit the passage of a needle. Similarly in experimenting with heavy flanges, in which the ratio of flange to body was as 8: 1, castings have been obtained in which the flange was completely severed from the body. In other instances the junction of the flange and body has presented a series of fine holes, and is technically known as "drawn." Any one of these features may be readily observed by casting a valve body with either heavy flanges or heavy bosses at a low casting temperature. But, in addition to the different rates of contraction, due to abrupt change in the section of the metal, a difference in crystallisation is to be noted. If during cooling from a molten condition certain strains are developed which affect the crystal growth or cause it to take a particular direction, such a retardation may give rise to planes of weakness, if not actual cleavage planes. As an instance, a rectangular casting sectionally shown in Fig. 2 may be cited. In cooling from a molten condition the four angles containing the greater mass of metal will be the last to solidify. The crystals will take their direction from the cooling surface, hence a disturbance is naturally to be expected in the corners; not only so, but each plate in process of contraction will tend to approach its own centre, thereby further weakening the corners. Evidently these angles, when the casting is subjected to hydraulic pressure, will offer channels which, though exceedingly minute, are none the less effective in admitting the passage of water to the exterior. This is intensified by the fact that the internal pressure tends to force the plates outwards or away from each other, thus facilitating the structural weakness of the angles and imperceptibly widening the routes along which the penetrating water travels. In rather an exaggerated manner this feature is diagrammatically shown in Fig. 3. The internal pressure, forcing each plate outwards and in the direction of the arrows, tends to intensify the already porous structure of the angles, and water will ooze through drop by drop in the direction indicated. Unequal shrinkage due to casting temperature will be dealt with in a later article. A further, though possibly rare, source of unequal shrinkage is that due to the form of runner or gate employed, and may be termed improper feeding. Such a fault occurs when the runner, instead of supplying metal to the

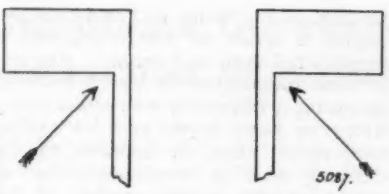


FIG. 1.

casting, draws from it, thus reversing the feeding process to the detriment of the casting.

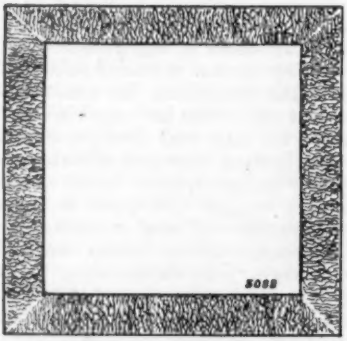


FIG. 2.

Apart from abrupt changes in the section of the metal, local conditions of cooling or of crystallisation may be such

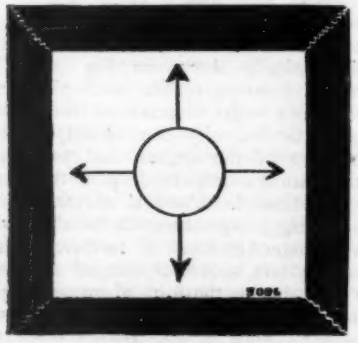


FIG. 3.

as to impair the crystalline cohesion, even in extreme cases resulting in microscopically minute interstices between adjacent crystals; conditions which at once favour the passage of a liquid under pressure. Molecular porosity, as far as steam-metal alloys are concerned, may be safely ignored; for, when a leakage does occur, it is always between the crystals and never through them.

Turning to the sixth condition, blow-holes and cold shuts, when present, are usually visible; the former, if not actually visible on the face of the casting, are usually exposed on machining. If, however, machining does not show them up, it can readily be imagined that a series of minute and connected blow-holes will account for leakages; a remark which also holds good for the presence of oxide or mechanically-held foreign matter, a chain of such material readily offering a route for the passage of percolating water or steam through the casting. The presence of oxide is determined chiefly by the length of time the alloy has been maintained in a molten condition.

It may happen that the alloy is melted before the moulds are ready; in such a case, the usual plan is to draw the furnace-covers and hold the crucibles back until the moulds are finished—a practice exceedingly bad for any copper alloy. The best conditions, from a steam-metal point of view, are obtained by rapid melting, drawing the crucible from the furnace the moment the requisite temperature has been reached, and then casting. In no case should the alloy be cooked; in the event of sufficient moulds not being ready it is cheaper to pour the surplus metal into ingots and remelt again. Defects due to moulding or pouring are generally in the form of "scabs," "buckles," involved dirt, etc., and are usually of a character sufficiently vivid to indicate the remedy. Chaplets or studs are employed to hold the cores in position and to prevent them floating. They are made from the same alloy as that used for the casting. In the event of the alloy not fusing to the chaplet, so forming a "cold shut," a leakage will occur when the casting is tested, a

defect which is, however, usually apparent before testing.

Generally, however, the foregoing conditions are by no means insurmountable, and on the whole are not responsible for many of the castings rejected on steam or water trial. Due attention to the design of the pattern and careful foundry practice will overcome them. Experience proves that the majority of such rejections are due to reasons coming within either conditions 1 or 2.

The purity of the metal employed is naturally of moment, and here chemical analysis offers valuable aid to the founder. In addition, however, to impurities originally present in the metals employed to form the alloy, injurious elements may be accidentally introduced in melting practice. The accidental presence of iron is a very familiar example; mere traces of aluminium present in a steam or hydraulic alloy exert a most baneful influence, for whilst giving castings which to the eye present a really good appearance, an effect further improved by machining, yet such castings under steam or water trial hopelessly "sweat" or "blow." An accidental addition of this kind may occur by using a crucible which has previously held an aluminium alloy; such instances do occur, and only emphasise the necessity for exercise of ordinary care in melting practice. An example of this kind is sufficient to show how impurities may be taken up in the foundry. Passing on to the effect of impurities originally present in the constituent metals of the alloys, the following conclusions are given solely from a steam-metal point of view, and in a general rather than a detailed manner.

Commencing with a chemically pure metal, it is evident that such a metal will in mass be built up of perfectly pure crystals, and therefore if a section of this metal, after polishing and suitable etching, be examined under a high magnification, the junction of the crystals will be visible. A piece of metal for microscopical examination must necessarily present a plane surface, and as it is cut from the mass of the metal, the crystals themselves will naturally be "sectioned," and the junctions shown will take the form of a connected network, as, for example, in Fig. 4. This structure, when translated into the solid, will give a metal built up of polyhedral crystals. Assuming that this piece of metal be in the form of a casting ready for testing by water-pressure, and that the crystal cohesion has not been adversely influenced by any of the conditions already indicated, then the casting will hold water until the internal pressure becomes such as to disturb the crystalline continuity. Such a casting would therefore remain tight within the capacity of the metal to resist deformation.

If to this pure metal traces of other elements are added, the addition will, under certain conditions, combine with a portion of the metal to form a compound. On cooling this metal from a molten condition the compound so formed is rejected by the pure crystals to the crystal boundaries, and in section will therefore show as a network embracing the pure crystals. Sectionally such a structure is shown in Fig. 5, and translated into the solid this network takes the form of envelopes surrounding the otherwise pure crystals. The mechanical value of the metal has now become a factor of these envelopes; if the force required to separate the envelope from the crystal is equal to the original cohesion of the pure metal, then the tenacity will remain unaffected, but if the compound is of a brittle character then the tenacity is lowered to the extent of this brittleness. An addition of mere traces of certain elements may therefore, by the formation of a compound, bind the pure crystals together, and so strengthen the mass; on the other hand, the compound may be of such a character as to weaken or destroy the crystalline continuity. The capacity for resisting internal liquid pressure is influenced in a similar manner by these envelopes. Assuming that the compound so formed has a solidification point somewhere near that of the pure metal, and also a similar contraction coefficient, then it follows that in process of cooling from a molten condition, and with uniform contraction, the whole structure will be interlocked; that is, crystal and compound will be firmly dovetailed one into

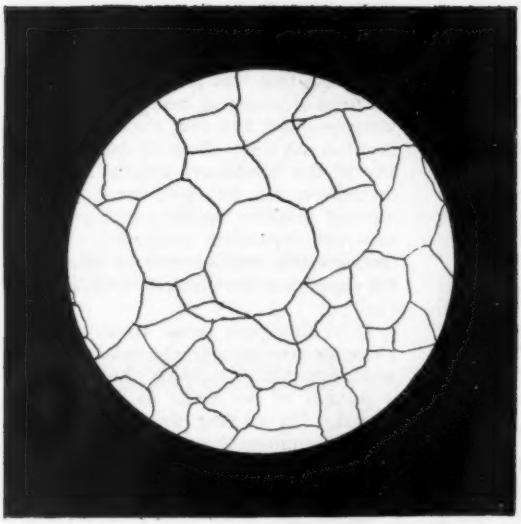


FIG. 4.

the other. Such a casting would successfully resist all pressures within its limit of deformation. If, however, the solidification point of the compound be lower than that of the pure crystals, then, evidently, it will remain liquid some time after the major part of the metal has solidified, and in process of further cooling and contraction may give rise to microscopically minute interstices between the crystals, the compound thus effectually destroying continuity. These minute interstices, if continuous, offer favourable routes for the passage of liquid or of steam. For instance, assuming in the case of Fig. 5 that the difference in contraction between the pure crystals and the compound network is such as to give rise to a series of connected interstices, then the fine hair-line shown across the structure would be obtained. For convenience, this line is shown in the centre of the compound, actually it would lie between the compound and the crystals. Imagine the whole structure to be minutely fissured in this manner, and some conception of the behaviour of the casting under water-trial will be obtained. Figuratively, a channel is presented between each crystal and its surrounding envelope for the percolation of water, which, oozing through, up and down between the crystals, eventually finds its way to the exterior, there showing as a film of moisture, if not in certain extreme cases as an actual jet of water. An actual photomicrograph of a pure metal, containing the merest trace of a foreign element, is shown in Fig. 6 at a less magnification than that of Fig. 5.

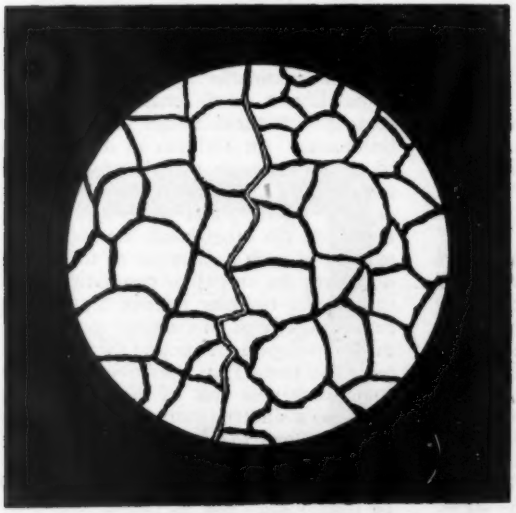


FIG. 5.

A further feature of interest is found in certain, though possibly extreme, cases in which the melting point of the compound may be so low

as to be affected by steam of high temperature. Thus a casting, whilst tight when tested at atmospheric temperature, may, when under steam trial, "blow through" owing to the compound softening, if not actually liquefying, thereby offering a route for the passage of steam.

Generally speaking, metals of high fusibility are more tenacious than those of lower melting-points, instances of which are found in a comparison of lead and copper or of copper and iron. It would also appear, that if the addition of a trace of another element to the metal gives rise to a compound having a solidification point near or higher than that of the metal, then the mechanical and water-resisting properties of the metal are not impaired, but may possibly be improved. If however this addition gives rise to a compound having a solidification point much lower than that of the metal, then these properties are impaired if not actually destroyed. Carrying these from the metal to the alloy it follows that if a compound of low fusibility is present in a steam metal alloy, both its mechanical and steam-resisting properties are affected. An alloy containing several constituent metals in passing from a liquid to a solid does not freeze as a whole, but presents several distinct solidification points. The first crystals to separate out or solidify are those of the highest fusibility. As the temperature falls these are followed by the next in order of succession, and so on until the whole mass assumes a solid condition. As a typical instance, the cooling of an alloy of copper with five per cent. tin may be taken. On cooling from the molten condition, the solidification point of copper is reached and crystals of free copper separate from the liquid; these crystals reject the copper-tin compound, which remains liquid until with a further fall in temperature it solidifies at about 930 degs. Fahr. If this copper-tin alloy contain lead, then a further solidification point is shown at some 300 degs. Fahr. lower than that of the copper-tin compound. In a triple alloy of this character three distinct freezing points are shown, which will naturally range in intensity according to the constitution of the alloy. Thus if lead be present in large excess the alloy will remain fluid long after the first two freezing points have been passed, the solid particles of copper and of the copper-tin compound remaining suspended in the molten lead. On the other hand, if copper be in excess, reverse conditions will prevail. Therefore in all triple or quadruple alloys of the steam metal type several distinct freezing points are shown, and none of these alloys solidify as a whole. To the founder the chief interest of this question lies in the difference of temperature between the first and last solidification point; the nearer these points approach each other the better for the mechanical and steam-resisting properties of the alloys, and conversely as their distance apart widens these properties are impaired. The last freezing point in the passage of a liquid alloy to the solid condition represents the solidification of the mother liquor or eutectic. If impurities are present which retard or delay the freezing of the eutectic then the steam-resisting properties of the alloy are impaired; on the other hand, if by the addition of any element this freezing point can be raised, then it should follow that the resistance offered by the alloy to the passage of steam will be increased. For instance, the addition of traces of arsenic to high-pressure steam fittings has long been followed in brass-foundry practice; and this addition appears to raise the temperature at which the eutectic freezes. The writer has, as yet, had no opportunity of investigating this point further than by making the castings and testing them with steam of high pressure and temperature. It is, however, of interest to note that arsenical copper in the form of locomotive fire-boxes yields, in comparison with similar fire-boxes of arsenic-free copper, a longer working life. Arsenical copper at temperatures above normal appears to possess a greater tenacity than does arsenic free copper, as shown by the late Sir Wm. Roberts Austen. In his hands ordinary copper tested at a temperature of 300 degs. Cent. gave a tenacity of 9·38 tons per sq. in., whilst arsenical copper tested at the same temperature yielded the higher result of 12·6 tons per sq. in.

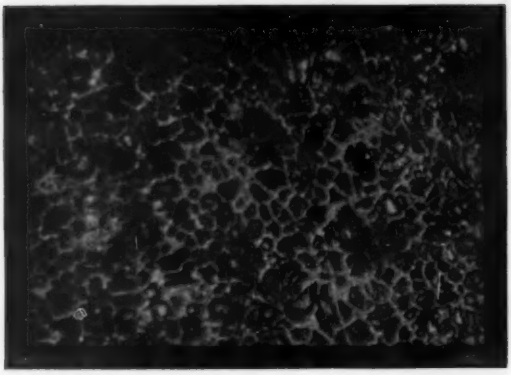


FIG. 6.

A further illustration of the increase in certain properties obtained by raising the solidification point of the eutectic is supplied by the research of G. H. Clamer.* Mr. Clamer found that by keeping the tin at a content of 5 per cent. in a triple alloy of copper, tin, and lead, the amount of the latter metal carried by the alloy could be considerably increased. On cooling such an alloy from the molten condition, an investing membrane of the copper-tin compound is formed, which imprisons or traps the still liquid lead, thereby preventing segregation and retaining the mechanically held lead evenly distributed in the cold alloy. It was also found that the addition of a trace of nickel raised the freezing-point of the copper-tin eutectic, and by so doing it imprisons the fluid lead comparatively early in the solidification process, and completely prevents any chance of segregation of lead. In this way Mr. Clamer has successfully produced alloys containing up to 30 per cent. lead.

The influence of impurities may, from a steam or hydraulic metal point of view, only be summarised as follows. If the presence of an impurity gives rise to the formation of compounds of low fusibility and of differing contraction coefficients to the mass of the alloy, it follows that on final solidification the mass will be more or less microscopically fissured. No matter how fine these fissures be, indeed they may be beyond the range of microscopic vision, they are, when tested by water, minutely opened, admitting the liquid to ooze through in an imperceptible manner, forming a film of moisture on the external portions of the casting.

If an element be present which gives rise to an exceedingly sharp crystallisation, or to crystallisation in a particular direction, or if the cohesive force between the crystals be lessened, as, for instance, along well-defined cleavage planes, such planes or routes of particular direction will admit the passage of a mobile liquid under high pressure. Further, the crystal cohesion being weak in a certain direction, it follows that the internal pressure of the casting will disturb the crystals in the locality of the weakness, allowing water to pass between them from interior to exterior. Such a disturbance would, of course, be exceedingly minute and far beyond ordinary visual recognition. The sum-total of the influence of any impurity is its effect determined by the method of combination with other members of the alloy, and the resultant influence of this compound on the solidification and on the crystallisation. The ideal type of crystallisation is one in which the crystals are powerfully interlocked one with another, the cohesive force holding them being equal to or greater than the tenacity of the crystals themselves. Such a structure would present no definite crystalline direction, but would, on the whole, show a broken-up (or interlocked) structure characteristic of a forged metal.

* A Study of Alloys suitable for bearing purposes. Journal Franklin Institute. Vol. CLVI. No. 1.

PERCY LONGMUIR,
Carnegie Research Scholar.

(To be concluded.)

NOTES ON LOCOMOTIVE AND RAILWAY ENGINEERING.

The Coned-Ring Boiler.

A NUMBER of communications have been received, bearing upon a statement which recently appeared in the columns of a contemporary, to the effect that the coned-ring which forms such a prominent feature of recent Great Western locomotive boiler construction provides additional heating-surface area. The majority of the correspondents express a wish to learn the views of the writer of these notes on the point.

The writer has carefully examined the general arrangement drawings of one of these boilers, and cannot discover any grounds by which the claim that has been made on behalf of the coned-ring—viz., that it increases the heating surface—may be substantiated. The total heating surface of the "City" class engines on the Great Western Railway is 1818·12 sq. ft., whilst that of the "Atbara" class, which preceded them, is 1663·02 sq. ft., a difference of 155 sq. ft. in favour of the later engines with the coned-ring. Of this 155 sq. ft., no less than 151·7 is contributed by the tubes, which are, of course, wholly unaffected by the presence of the coned-ring, so that, even supposing that the latter does lead to the heating surface being increased in any way, it is only to the extent of 3·34 sq. ft., which is altogether too insignificant a figure to warrant the introduction of such a radical departure from customary practice as that in question, involving as it does the highest development of the boiler-makers' art in its manufacture.

The coned-ring method of construction presents certain definite advantages, notably those of increased steam space and a greater water volume; but it cannot be urged that it is of value so far as augmenting the heating surface is concerned. The statement of the original writer who remarked that "the taper boiler has great merit as a steam generator, as owing to the way it spreads out towards the big Belpaire fire-box it provides a *largely increased* heating surface just in the very spot where that is most useful and efficient—viz. close to the source of heat"—appears to be totally unjustified by the actual facts, as much so indeed as would the introduction of the coned-ring itself be if its only advantage were that of adding 3·34 sq. ft. of heating surface to the fire-box, as it is alleged to do in the engines referred to.

The same writer at a later date attributes the advantage possessed by the "taper" boiler to the fact that "the largest cross-sectional area of the boiler-barrel is in the locality where the heating surface is most valuable—viz. close to the fire-box." This, of course, is *quite* another matter.

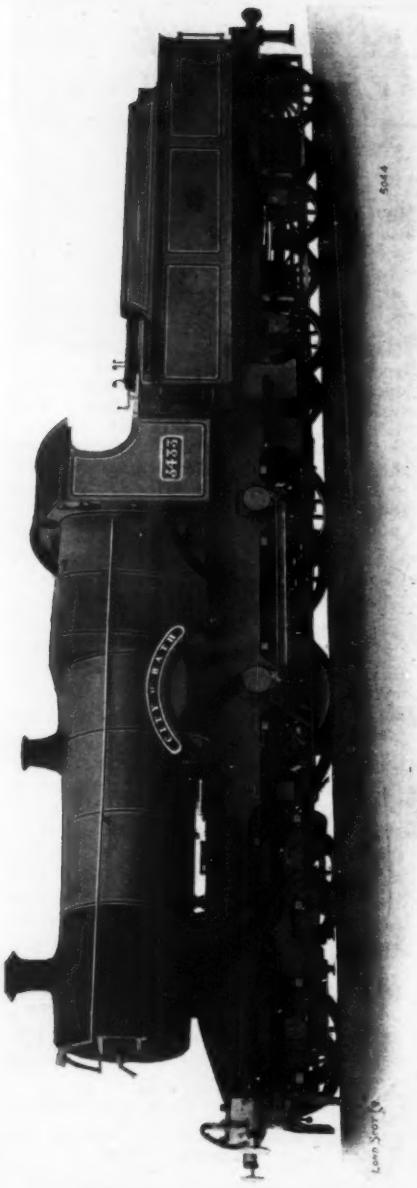
The true reason for the largely increased heating surface of the Great Western "Cities," as compared with the "Atbara" is to be found among the dimensions given below under the heading of boiler diameter and number of tubes :—

"CITY" CLASS ENGINES.

Boiler-barrel, length ...	11′ 0″	
,, diam. outs	4′ 10⅛″	& 5′ 6″
Fire-box, outside ...	7′ 0″	× { 5′ 9″ / 4′ 0″
,, inside ...	6′ 2 5/16″	× { 4′ 9″ / 3′ 2⅝″
,, height ...	6′ 6 7/16″	× 5′ 0 7/16″
Tubes, number... ...	350	
,, diameter ...	1⅝″	
,, length	11′ 4 5/16″	
Heating surface tubes...	1689·82 sq. ft.	
,, fire-box	128·3 ,,	
Heating surface total ...	1818·12 sq. ft.	

"ATBARA" CLASS ENGINES.

Boiler-barrel, length ...	11′ 0″	
,, diam. outs	4′ 6″	& 4′ 5″
Fire-box, outside ...	7′ 0″	× { 5′ 0″ / 4′ 0″
,, inside ...	6′ 4 1/16″	× { 4′ 4⅛″ / 3′ 4⅛″
,, height ...	5′ 11 1/16″	& 4′ 11 1/16″
Tubes, number ...	277	
,, diameter ...	1⅝″	
,, length	11′ 3⅜″	
Heating surface tubes...	1538·06 sq. ft.	
,, fire-box	124·96 ,,	
Heating surface total ...	1663·02 sq. ft.	



EXPRESS PASSENGER LOCOMOTIVE WITH CONED BOILER: GREAT WESTERN RAILWAY.

High-Capacity Wagons on the Caledonian Railway.

Mr. J. F. McIntosh, the locomotive superintendent of the Caledonian Railway, has favoured the writer with some detailed particulars on the above subject, which will, no doubt, be of great interest to the readers of these notes.

The railway company in question will shortly have between 500 and 600 wagons, each of 30 tons carrying capacity, in operation, and also several 40-ton hopper wagons and 50-ton iron ore wagons. The company's standard mineral wagon has a capacity of 16 tons, and can be negotiated at all the collieries and handled on all the shipping appliances at docks on the system. Mr. McIntosh expresses the opinion that the days of the 6-ton, 7-ton, and 8-ton wagons are practically past, and those having larger carrying capacities are rapidly taking their places for the conveyance of specified mineral traffic. So long as the present high-pressure competition between railway companies exists there will necessarily be a difficulty in using high-capacity wagons for ordinary merchandise traffic, as each railway company is more anxious than its competitive neighbour to secure and deliver goods traffic in the shortest possible time, consequently goods wagons are often run with small tonnage of paying load; therefore there is no prospect of any alteration being made in the carrying capacity of the goods plant.

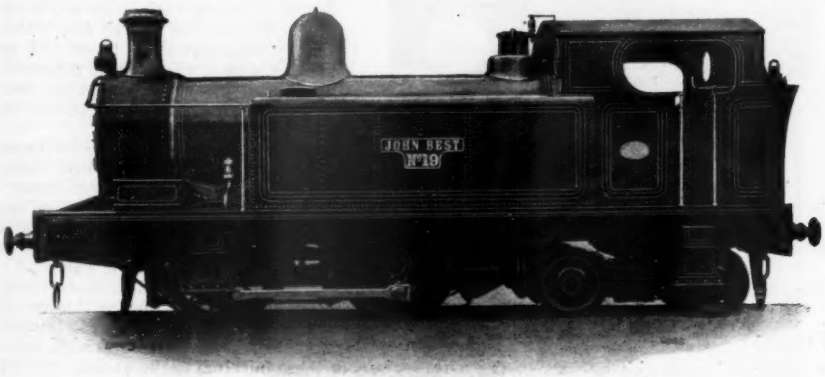
Great efforts, however, are being made by all railway companies to have their goods wagons loaded up to their full capacity, and also to make up full loads at interchangeable points. Nevertheless, as already stated, the keenness of the competition for railway traffic, and the desire for early delivery of the goods at their destination, entirely destroy the chance of adopting wagons of large carrying capacity for transit of merchandise traffic. If this difficulty could be overcome there is no question about the large wagon being the best in every respect for all classes of traffic. The principal advantages are the lightness of the tare weight or non-paying load in proportion to paying load, the avoidance of the enormous amount of shunting that is involved in separating small wagons,

the greater amount of siding accommodation afforded, and lesser expense in keeping the wagons in repair. Summing up, Mr. McIntosh remarks that no doubt can exist that the high-capacity wagon is the most profitable type for railway companies from every point of view, and it is to the general adoption of such vehicles that railway companies must look for one of the factors in reducing the cost of railway working.

The foregoing views, emanating as they do from one who is in a position to speak with the greatest amount of authority, will no doubt form a valuable addition to what has already been published relating to the subject.

The writer is also indebted to Mr. Jas. Holden, Locomotive, Carriage and Wagon Superintendent of the Great Eastern Railway, for specifications and full working drawings of 10, 12, 15, 20 and 30 tons "Private owners" wagons. These specifications and drawings have been issued by the Committee of the Railway Clearing House, of which body Mr. Holden is Chairman.

The principal portions of the drawings will be published from time to time in these columns, accompanied by extracts from the respective specifications.



CONTRACTORS' LOCOMOTIVE USED ON TALLA WATERWORKS CONTRACT, EDINBURGH.

Cylinders, 18 ins. diam. by 26-ins. stroke. Coupled Wheels, diam. 4 ft. 6 ins. Boiler Barrel, 10 ft. 7½ ins. by 4 ft. 5 ins. Total Weight loaded, 48¼ tons.

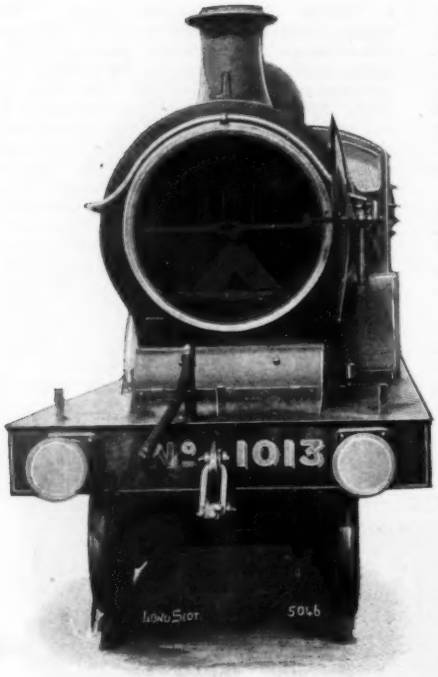
A Novel Type of "Contractors" Locomotive.

The majority of contractors' locomotives, as everyone knows, are provided with six-coupled wheels of about 4 ft. in diameter and a "saddle" tank over the boiler. The engine illustrated herewith is far more in accordance with recognised passenger tank-engine design than that usually adopted for contractors' purposes. Upon the Cathcart circle line in the Glasgow district, for instance, not to mention numerous others, locomotives similar to that shown are extensively used on light passenger trains. The engine "John Best," however, is exclusively employed on contractors' work, and was built for that purpose by Messrs. Hudswell, Clarke & Co., Ltd., of Leeds. This firm states that, so far as they are concerned, the design is absolutely unique for the conditions of service for which it was supplied; therefore it is pleasing to learn that the engine is giving every satisfaction, and from all indications is equal to the work required of it.

It was built in 1902, to the order of Mr. John Best, who has the Talla Waterworks contract for the Edinburgh Corporation in hand. It runs between Broughton Station on the Caledonian Railway and Talla. The road is a permanent one, but the gradient is heavy and the curves sharp. This marks an interesting departure from customary practice as applied to contractors' locomotives.

Smart Work on the Great Central.

When dealing with the subject of the Great Central Company's Sheffield service in last month's notes, the writer referred to



SMOKEBOX END VIEW OF FOUR-COUPLED BOGIE (4-4-0) EXPRESS PASSENGER LOCOMOTIVE, GREAT CENTRAL RAILWAY.

other experiences with engines of the 1013 class. These were briefly as follows: No. 1019 ran from Sheffield to Penistone, 12¾ mls. of continuous up-grade, ranging from 1 in 132 to 1 in 120, with a load equal to 15 coaches in the net time of 19 mins., including starting and stopping. No. 1017 covered the distance between Manchester (London Road) and Sheffield, 41¼ mls. (the first 22½ of which—viz., to Dunford Bridge—is adverse gradient), in 55 mins., including stops at Guide Bridge and Penistone, and ¾-ml. flag-signalling through Gorton Yards and beyond, the load in this instance being equal to 12 coaches; and finally No. 2015 started from Leicester 9 mins. late, and arrived at Marylebone 3 mins. early, having covered the 103 miles in 121 mins. with the equivalent of a 13½ coach load behind the tender. This included slackenings at Quainton Road and at the Aylesbury curve, followed by the long climb to Amersham, which was severely felt owing to the bad start resulting from the reduction of speed at Aylesbury station. Upon each of these occasions the writer noted the performances of the engine from the footplate, and can testify to the ease with which the work was accomplished in every instance.

Exhaust Steam Injectors for Locomotives.

The superiority of the exhaust steam injector over those of the ordinary pattern is now generally admitted. It is only necessary to study the working of the two types to recognise the advantages, both in respect of efficiency and economy, which are possessed by the former.

It is, of course, highly desirable that the temperature of feed-water should be raised to the highest possible degree at which the injector will work before it enters the boiler; and if this can be accomplished by means of exhaust steam, which would otherwise go to waste, it is easily apparent that a great saving must of necessity be effected.

It is well known that the ordinary pattern of injector will not work satisfactorily if the water is even moderately warm; but in the case of the exhaust steam injector it can be and is easily delivered into the boiler at a temperature of 270 degs. Fahr.

The inventors and manufacturers of this apparatus, Messrs. Davies & Metcalfe, of 4, St. Ann's Square, Manchester, have supplied large numbers of these injectors to the various railway companies, and the results attained have been uniformly satisfactory. The method of working may be clearly followed by examining the drawing. Leading off from the blast-pipe of the locomotive is a branch pipe, by means of which steam is conveyed to what is termed the exhaust portion of the apparatus, situated below the footplate. Here the exhaust steam is brought into contact with the water, before reaching which, however, it has been freed from any oily impurities or water present by means of a grease separator clearly shown in the illustration.

The velocity of the exhaust steam as it passes along the pipe is so low that it only induces a small amount of vacuum in the combining cone, and into this the water flows, condensing the steam, and allowing more steam to enter; this collects more water, and in this manner the injector performs its work.

The supplementary portion of the apparatus

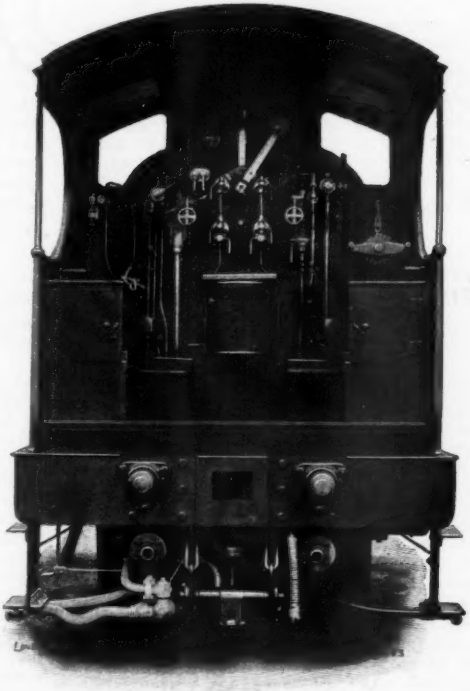
which is fixed to the firebox in front is worked entirely by live steam, and the water, after it leaves the exhaust portion below the footplate at 200 degs. Fahr. and a pressure of 70 lbs., is heated up to 280 degs. in the supplementary portion and delivered to the boiler at that temperature, as stated earlier. A wing valve is provided in the exhaust steam pipe just before the injector, having a branch cast on for the attachment of a live steam pipe from a small valve on the boiler, so that when the engine is standing or running with the regulator closed steam from the boiler performs the duties ordinarily carried out by the exhaust steam.

Locomotive performance on the London and South Western Railway.

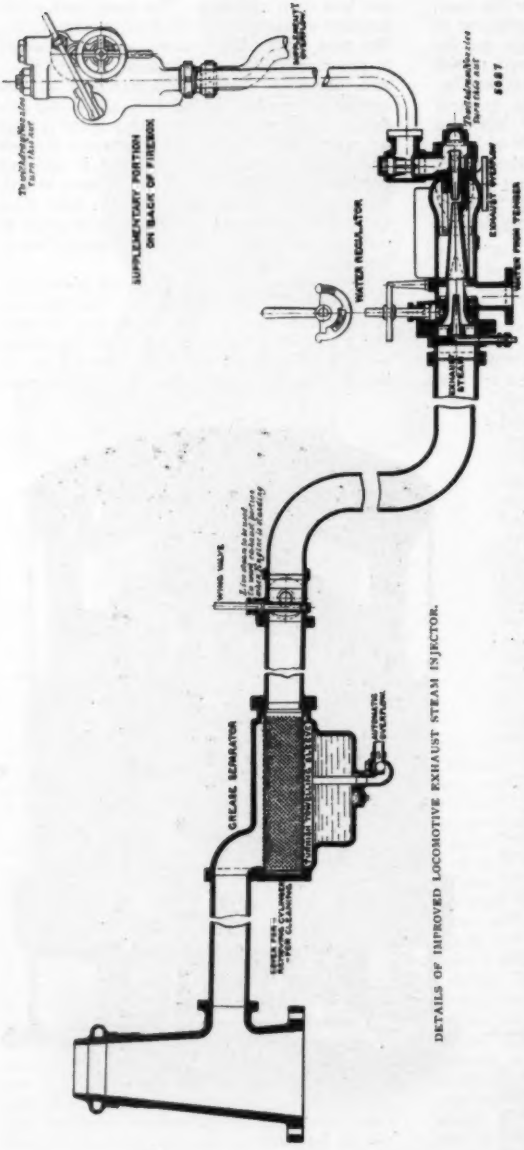
By the courtesy of Mr. Drummond the writer has been enabled to note the work performed by the locomotives employed in hauling some of the fastest and most important trains on the London and South-Western Railway. On each occasion the engines used were those of Mr. Drummond's well-known 4:4:0 type, having 7 ft. 7 in. coupled wheels, 18½ in. × 26 in. cylinders, and, with one exception, cross water tubes in the firebox. As is generally known, the South-Western Company is doing all in its power to popularise its route to Exeter, which route, besides being the shortest from London, possesses advantages which lovers of the picturesque will not be slow to appreciate. The first trip made by the writer was by the Plymouth corridor luncheon express, leaving Waterloo at 11 a.m., and which is timed to perform the journey to Exeter in 3 hrs. 15 mins., with a stop of 5 minutes at Salisbury; the total distance being 171½ mls. and the net running-time 190 mins. Even with a moderately graded line this timing would be in all respects excellent, but when the difficult character of the road between Salisbury and Exeter is taken into account it may be fairly described as exceedingly meritorious. Starting away punctually at the appointed time from Waterloo, engine No. 708 covered the first stretch of 83½ mls. in 91 mins., the load behind the tender up to this point representing a total weight of not less than 200 tons. The most noticeable features of this portion of the trip were firstly, the ease with which steam was maintained at practically blowing-off point (viz. 175 lbs.), and, secondly, the great smartness of the engine in running on the up grades. As evidence bearing upon this latter point it may be stated that the 10 mls. between Byfleet and Sturt, all of which distance is adverse gradient averaging from 1 in 388 to 1 in 298, was covered in 11 mins. 5 secs., and later the 3 mls. of 1 in 249 between mile posts 48 and 51 were traversed in the good time of 2 mins. 57 secs.

Some remarkable running took place west of Salisbury. The engine was No. 707, one of the same class as that which had brought the train from London, but differing therefrom in being fitted with a six-wheeled tender instead of the heavy double-bogie pattern

The exhaust portion of Davies & Metcalfe's Exhaust Steam Injector is seen here—



INTERIOR OF CAB, GREAT CENTRAL RAILWAY COMPANY'S FOUR-COUPLED EXPRESS PASSENGER LOCOMOTIVE, 1013 CLASS.



DETAILS OF IMPROVED LOCOMOTIVE EXHAUST STEAM INJECTOR.

which Mr. Drummond now provides on all his latest designs. It may be remarked in passing that the use of water-troughs is found to be impracticable on the London & South-Western Railway, owing to the fact that sites cannot be found for them where a level stretch of road and a supply of suitable water are conjointly present. At Salisbury an extra bogie coach was added to the train, thereby increasing the load to about 220 tons; and with this weight behind the tender, engine No. 707 covered the 88¼ miles to Exeter in 98 mins., arriving precisely at the advertised time—viz. 2.15 p.m. Included in this timing were two permanent-way slacks—viz. at Abbeyford and Chard Junction — whilst speed had to be considerably reduced when passing over the severe curve through Yeovil Junction. The Honiton incline, 7 miles in length, with a ruling gradient of 1 in 80 and ¾ mile of 1 in 70, was surmounted in a fraction over 9 mins.; and the subsequent running down the other side, after passing through the tunnel, was very smartly performed. On the return trip No. 286, another 6 ft. 7 ins. four-coupled engine of Mr. Drummond's design, but without the water-tubes, took a load equal to 14 coaches from Exeter to Salisbury, with stops at Yeovil, Sherborne, and Templecombe, in 2 hrs. 6 mins. Eight minutes of this allowance were consumed by the three stops, and a further delay of 3 mins. was occasioned by the late arrival of the Somerset and Dorset train from Bournemouth.

Leaving Salisbury 5 mins. late on the final run to London, another of the water-tube class (No. 307) gave a capital exhibition of fast running. The whole of this concluding portion of the trip was performed after darkness had set in, so that the writer was able to note the almost total absence of sparking which was displayed. This desirable result is obtained by the use of Mr. Drummond's

patent spark arrester and fuel economiser with which apparatus these engines are fitted. Only very occasionally was a stray spark emitted from the chimney, whilst the engine steamed with the greatest freedom the whole of the time. The 83½ mls. were covered in 1 hr. 35 mins., including a permanent-way slack at Byfleet, reduction to 30 mls. per hour through Clapham Junction and the necessarily tardy approach to Waterloo Station. The run-up from passing through Basingstoke was performed in 50 mins. net time; 47¾ mls. The writer was afforded an opportunity of examining the coal and oil sheets in the Locomotive Department Offices at Exeter, and was surprised to learn that the engines are performing the arduous duties described above on a coal consumption ranging between 30 and 35 lbs. per mile. With locomotives of such proved efficiency at their disposal, there can be no fear of the London and South Western Railway Company losing in any degree the firm hold which they have at present on the Exeter traffic. To Inspectors Mitchell and Harle of the Guildford and Exeter Locomotive departments respectively, who at Mr. Drummond's request accompanied the writer on the outward journey, the one between London and Salisbury and the other between the latter place and Exeter, many thanks are due for their kindness in rendering every assistance in noting the work done and supplying information *re* distances, gradients, &c.

The "Piloting" System.

On some railways—notably the London and North-Western—the practice of employing two locomotives for hauling the heaviest passenger trains is a growing one.

This is a subject upon which much has been written, and many people have gone out of their way to record opinions as to the necessity or otherwise for "double-heading" the principal trains. The uninitiated have ventured so far as to hint at inefficiency on the part of Mr. Webb's latest engines, and to presume them unable to deal with the loads unassisted; whilst others, whose opinions are avowedly based upon experience with the particular engines cited, impute reasons almost, if not quite, as wide of the mark as those advanced by the first-named section.

Those who are personally acquainted with Mr. Webb know very well that he never has been in favour of employing a second engine, except in cases where it would be unreasonable to expect one to keep time, and he always was, and still is, absolutely confident that his four-cylinder compounds, especially those of the "Alfred the Great" class, are fully equal to the task of hauling the majority, if not all of the regular express passenger trains, single-handed, on any section of the London and North-Western main line, excepting, of course, some of the hilly districts, where it is more advantageous to use locomotives having coupled wheels of lesser diameter than 7 ft.

The existing rule that all trains made up of over 17 coaches must be run by two engines is, of course, a purely Traffic Department order, and has never been recognised as justifiable at Crewe. It must be remembered that the average train weights on the London and North-Western Railway are largely in excess of those on other lines, and the number of runs of 100 miles and upwards without a stop are also more numerous, so that the plea of its being necessary to "fix a standard load" for one engine to haul has something in it perhaps, but that load would doubtless have been estimated at the equivalent of 19 or even 20 coaches if Crewe had decided the point, seeing that the engines have frequently demonstrated in the past their ability to keep time with what is known as a 22-coach load. The present method of working is certainly opposed to the observance of economy, and that, in these days of high-pressure competition, is a serious consideration.

An Unfounded Rumour.

A statement has been circulated in a portion of the engineering and general press to the effect that the London & North-Western Railway Co. are about to give the "Smith" three-cylinder compound system a trial, and that an engine constructed on this principle has been put in hand at Crewe Works. The writer is in a position to state that there is no foundation whatever in the report referred to; neither is the construction of such an engine contemplated for the London & North-Western Railway.

* * * * *

In the description of the Great Central Co.'s new route to London which appeared in last month's notes, the name of Mr. C. A. Rowlandson, M.Inst.C.E., Chief Engineer of the Great Central Railway, who is responsible for the two lengths of the new line in question, was inadvertently omitted. The writer much regrets the fact, as it was entirely owing to the courtesy of Mr. Rowlandson that the facilities for obtaining the particulars were forthcoming.

CHAS. S. LAKE.

TOPICS OF THE MONTH.

"Free Trade" and British Exports.

SINCE our last issue went to press, three striking developments have been made evident in the first truly great question that has been put to the British nation in the present century. The Prime Minister has unreservedly decided in favour of a revision of what is euphemistically termed our fiscal "system"; the promised Blue-book has been published, containing statistical and other material relative to the conditions of trade prevailing under present conditions; and Mr. Chamberlain has unfolded his proposals for the rehabilitation of British industries, and the closer commercial union of the Mother Country with the scattered States of the Empire.

Our readers are aware that we have consistently condemned the so-called "free trade" that has contributed so largely to the decadence of some industries in this country, checked the natural development of others, and proved to be a most formidable weapon in the hands of our foreign rivals.

Therefore, we rejoice that the nation is at last aroused from a fifty years' slumber, and begins to inquire into some of the events that have taken place during the interval. The awakening has been rude and sudden—so sudden, in fact, that while the nation rubs its sleepy eyes, the voices of some are still heard recounting the dreams of bygone days. Two courses lie before the people—one to rise with the mind to be up and doing; the other to sink back with the murmured cry, "Let me sleep again." We are firmly convinced that the latter course will not be followed at the present critical period in the history of the British nation. It may well be that all will not immediately realise exactly what it is best to do, but we are sure that a vast majority of the people already see that something must be done.

Mr. Balfour's "Economic Notes on Insular Free Trade" serve as an education for those who sincerely ask for guidance, and as a most excellent introduction to the subject now occupying the public mind. Everyone who has not yet obtained a copy of the pamphlet should immediately do so. It is a striking example of lucid writing, and of closely-reasoned logic, that cannot fail to be appreciated even by those who are at present unprepared to accept all the conclusions reached.

Like many others who have convinced themselves that protection of our national industries has become necessary, Mr. Balfour announces himself as a "free trader." But he makes it perfectly clear that protection is the only means at our disposal for obtaining an approach to free trade, or even moderately fair treatment from a protectionist world. There is in this country a very bad habit, apparently inseparable from political warfare, of using watchwords and nicknames intended to do good to the inventors and harm their opponents. As Mr. Balfour says, "Popular disputation insists on labels, and likes its labels old." Hence the terms "protection" and "free trade" are frequently defined in accordance with the standards of fifty years or more ago, and the protectionist is held up to scorn as a man who tenaciously clings to the exploded fallacies of a bygone age. Protection is sometimes described as the unfair and illegitimate bolstering up of something that is assumed to be too feeble to exist without extraneous aid, and that only deserves to be left to die a natural death. Free trade, on the other hand, is often described as a principle giving fair play to commerce, and

removing all artificial barriers raised by protection against progress and natural development.

No attention should be given to the labelling tactics of the political arena, or the strained definitions of deluded theorists. Abstract theories do not always suit the actual conditions of life, and those to whom such theories are most dear, fail to apply them to the conduct of their own affairs. To the man with a sensible and well-balanced mind, the law of self-preservation is perfectly legitimate. He adopts every available means for the protection of his life, his health, and his property. Only such consistent fanatics as the Peculiar People refuse adventitious aid. Nations that are governed by sensible men very properly take precautions for the protection of their native lands by the establishment of armies and navies. Universal disarmament may be very beautiful as a theory, but in practice no one nation in a world armed to the teeth can afford to put off its armour or to lay down its weapons. Similarly, in the world of commerce, no one nation can afford to lay aside protection unless other nations do the same.

The experiment was tried some sixty years ago by this country, and it was then believed that other countries would follow the lead thus given. But they did not, for it was immediately perceived that this quixotic venture gave them an unexpectedly favourable opportunity of profiting by our folly. Instead of diminishing, protection has everywhere increased. By its aid nation after nation has built up important manufacturing industries, and we have been shut out from market after market, until at last we are no longer in a position to compete on level terms with the rest of the world, and even our home markets are disturbed and overrun by manufactured goods from other countries. These evils have resulted, in the first place, from the injudicious application of an abstract theory; and, in the second place, from blind adherence to its experimental application after experience had shown its utter incompatibility with the true interests of the nation.

In Mr. Balfour's pamphlet we have an able demonstration of the impracticability of one-sided "free trade." He shows that if the prosperity of the country is to be maintained, the home market must be protected from the depredations of the foreigner, and that for its protection we must take up and use the shield and the weapons that were flung aside years ago, and once more assert our rights to fair and equitable treatment. The concluding appeal for freedom to negotiate, so that freedom of exchange may be increased, is one that surely will not fall upon deaf ears.

On the last page of the book some figures are given that constitute convincing proofs of the present necessity for action. Table I. shows the exports to protected and unprotected markets, of all articles of British production, with the exception of coal, machinery, and ships. These three items are omitted because each of them furnishes to foreign rivals the means of competition with our own industries, and therefore represents a class of trade that cannot be of ultimate advantage to the country at large.

TABLE I.

BRITISH EXPORTS TO PROTECTED AND UNPROTECTED MARKETS.

(Coal, Machinery, and Ships Excluded.)

Year.	All Countries.	Principal Protected Foreign Countries.	Principal Protected Colonies.	All other Countries and Colonies (except India).	India.
	Values in Million £ units.				
1880	205·4	87·1	11·4	106·8	29·2
1890	228·1	89·4	13·4	125·1	31·3
1900	224·3	80·9	12·8	130·5	27·7
1902	231·2	76·6	14·8	139·6	29·7

In this table, three striking features are evident, (1) the serious fall in the value of exports to protected foreign countries, (2) the gratifying rise in the value of exports to the principal protected colonies, and, (3) the increased value of exports to unprotected markets. The figures afford proof of the fact that while our manufacturers are fully capable of holding their own when fair play is accorded, they cannot possibly do so in the face of prohibitive tariffs.

Examination of the figures shows, further, that while the percentage distribution to unprotected markets increased from 52 per cent. in 1880 to over 60 per cent. in 1902, the proportion distributed to protected foreign countries, decreased from 42 per cent. in 1880 to a fraction more than 33 per cent. in 1902.

It may, perhaps, be said that the general volume of export business has remained satisfactory, and that it is unnecessary to worry about the incidence of distribution. This would be a very foolish way of looking at things, for we ought properly to have the same share in the increased trade of foreign countries as in that of the colonies. Every department of a well-conducted business concern is expected to show continued progress; and if it does not, there is evidently something wrong. If the figures presented by Mr. Balfour be considered in connection with the population of the country, it will be seen that even the aggregate value of the export trade does not give reasonable ground for satisfaction. For the purpose of such comparison, the figures in Table II. are given, the years selected being those for which the decennial census was in each case first available and the years falling midway between them.

TABLE II.

BRITISH EXPORTS TO ALL COUNTRIES
(Coal, Machinery, and Ships excluded.)

Year.	Value of Exports in Million £ Units.	Value of Exports per head in £ Units.
1881	215,277	6·2
1886	193,186	5·3
1891	213,270	5·6
1896	208,931	5·3
1901	222,726	5·4

Judged by this standard, the value of the exports per head of the population shows serious retrogression, and this undesirable development would be still more marked if it were not for the valuable assistance given by colonial trade. A little consideration will bring home two conclusions: (1) that modernised fiscal policy is required to enable us to secure equitable treatment from foreign nations; and (2) that preferential terms should be established between the Mother Country and the Colonies for the encouragement and further extension of British Empire trade.

Further light is thrown on the subject by the recent Blue Book, containing the results of the inquiry recently instituted by the Government. This volume comprises nearly 500 pages of memoranda, statistical tables and charts relative to British and foreign trade and industrial conditions. So voluminous is the mass of information presented, that we fear the majority of electors will shrink from the prolonged course of study that would be necessary for mastering the contents of the book.

Nevertheless, some of the figures stand out so clearly that their significance cannot be mistaken. One of the most important series of figures is contained in a table showing the value of exports of articles manufactured or partly manufactured in the United Kingdom.

Dealing first with exports to seven of the principal foreign countries, we give in Table III. a comparison of values for the years 1890 and 1902.

TABLE III.

BRITISH EXPORTS TO CERTAIN FOREIGN COUNTRIES.

Country.	1890.	1902.
Belgium	£6,766,000	£7,061,000
France	12,537,000	10,250,000
Germany	15,950,000	16,442,000
Holland	9,392,000	6,829,000
Italy	5,246,000	3,578,000
Russia	4,649,000	6,209,000
United States	29,089,000	19,468,000
Total	£83,629,000	£69,837,000

These figures indicate a drop of nearly 17½ per cent. in the exports of British manufactures to the countries named; and if we take the value of similar exports to all foreign countries, the result still shows a loss of nearly 12½ per cent. Thus, the exports to all foreign countries were:—

1890 ... ... £149,651,000
1902 ... ... £131,686,000

Taking next the statistics relative to British possessions during the same years, we have :—

	1890.	1902.
Indian Empire ...	£32,089,000	£30,873,000
Self-governing Colonies	35,516,000	52,211,000
Other Colonies and Possessions	11,549,000	12,875,000
Total	£79,154,000	£95,959,000

Here we find the satisfactory increase of about 20 per cent. in the value of manufactures taken by various States of the Empire, a condition that should convince the most hardened "Little Englander" that colonial trade is a thing to be fostered by every available means.

The following table shows very clearly the proportionate distribution of exports of British produce and of British manufacture to protected and unprotected markets, during the past 50 years :—

TABLE IV.

EXPORTS OF BRITISH PRODUCE AND MANUFACTURE (PERCENTAGE DISTRIBUTION).

	Principal Protected Countries and Colonies.	All other Countries and Colonies.
A.—Exports of all Articles of British Produce.	Per Cent.	Per Cent.
1850	56	44
1860	51	49
1870	53	47
1880	49	51
1890	46	54
1900	45	55
1902	42	58
B.—Exports of Manufactured and Partly Manufactured Articles.		
1850	57	43
1860	50	50
1870	50	50
1880	47	53
1890	44	56
1900	42	58
1902	38	62

From this table it is seen that within the period 1850-1902, the proportionate distribution of our total exports has been completely reversed, the proportions in 1850 being 56 per cent. to protected markets and 44 per cent. to other markets, whereas in 1902 the proportions were 42 per cent. to protected markets and 58 per cent. to other markets. Taking manufactured articles separately, the change has been even more marked, the proportions in 1850 being: protected markets 57 per cent., other markets 43 per cent.; and in 1902, protected markets 38 per cent., and other markets 62 per cent. It is shown by the Blue Book that the change has been a continuous one, but that it operated most rapidly during 1850 - 1860, and during 1890 - 1902. Further, it is made evident that there can be no doubt as to the effect of Continental and American tariffs in checking our export trade with protected countries, especially in manufactured articles.

Before proceeding to analyse the character of British exports, let us glance briefly at the records for British, German and American exports of manufactured goods. The Blue Book goes back to the year 1854 in the case of the United Kingdom and the United States, but the German records start from 1880. It would not give any true idea of the general trend of events in the present day to cite records which relate to a time when American industries were in long clothes, and when Germany as a nation was not born.

We therefore compare the exports of manufactured goods for the three countries during the years stated below :—

United Kingdom	(1883) ...	£215,000,000
,, ,,	(1890) ...	230,000,000
,, ,,	(1901) ...	222,000,000
Germany ...	(1883) ...	£98,000,000
,, ...	(1890) ...	107,000,000
,, ...	(1901) ...	145,000,000
United States...	(1883) ...	£28,000,000
,, ,, ...	(1890) ...	31,000,000
,, ,, ...	(1901) ...	86,000,000

Considering only the last eleven years here mentioned, we find that British manufactured exports have declined by 3½ per cent., while those of Germany and the United States have risen by 35½ per cent. and 174 per cent. respectively.

So far as we have gone, the figures agree

in showing that our exports of manufactured goods are steadily falling, while those of our rivals are increasing by leaps and bounds. Further, they indicate most clearly that if it were not for the increase of trade with the Colonies, the diminution in our exports would be nothing short of a national disaster.

A further comparison of the value of Colonial and foreign trade may be drawn by the aid of the classified statistics in Table V., compiled from the Board of Trade returns for 1902 :—

TABLE V.—Exports of Produce and Manufacture from the United Kingdom (1902).

Description.	Foreign Countries.	British Possessions.
	£	£
Living animals	676,000	146,000
Articles of food and drink	8,102,000	9,048,000
Raw materials	28,574,000	2,624,000
Yarns and textiles	65,170,000	38,163,000
Metals and manufactures therefrom	23,577,000	19,715,000
Machinery and millwork	11,599,000	7,155,000
Ships, new, not registered as British	4,547,000	1,325,000
Apparel	1,750,000	10,036,000
Chemicals and preparations	6,778,000	2,809,000
All other manufactures	21,295,000	16,309,000
Parcels Post	1,803,000	1,675,000
Unenumerated goods	522,000	26,000
Totals	£174,395,000	£109,029,000

Examination of these figures will show that foreign trade is of far less value to us than Colonial trade, for the reason that foreign countries take almost the whole of our exportations of raw materials, machinery and ships. We do not dispute the fact that profit may be made by the sale of raw material; but as coal, coke, and fuel represent no less than £27,580,000 out of the £31,198,000 value of raw material exported, the advantage is gained chiefly by colliery owners and coal merchants, and to a comparatively small extent by the working classes. Moreover, the exportation of raw materials places at the disposal of foreign manufacturers the means of competition with British industries. Machinery and ships certainly represent a considerable amount of labour, and their sale is advantageous for the present; but as both these classes of manufacture afford means by which foreigners are enabled to compete with British manufacturers and shipowners, the ultimate effect will be the diminution of exports and loss of labour

It is worthy of notice that in 1902 we sold pig iron to the value of £3,270,000 to foreign countries, a very unremunerative class of export as compared with iron or steel in the form of manufactured articles. The further note may be made that goods exported under the heading of manufactures frequently consist of material for further manufacture abroad. Cotton, jute, and linen yarns will serve as examples. Of these, foreign countries took value to the extent of £7,081,000, while the share of all British possessions only amounted to £1,694,000.

We have now said enough to show the important difference in the character of our trade with the Colonies and with foreign countries, and the difference would be still more striking if protected countries were considered separately from those in which open markets are still to be found. The further point should be taken to heart by everyone who has regard for the true welfare of the country, that the character of our export trade is becoming year by year more and more unremunerative—especially to the working classes. This is demonstrated by the following table :—

TABLE VI.

ANALYSIS OF BRITISH EXPORTS. (PERCENTAGE DISTRIBUTION.)

Year.	Food.	Raw Materials.	Manufactured Goods.
1882	4·7	5·1	90·2
1887	4·5	5·8	89·7
1892	4·9	8·5	86·6
1897	5·7	8·6	85·7
1902	6·1	11·0	82·9

Table VI. makes perfectly clear the general law, that the more raw material we sell to foreign countries, the fewer manufactured articles they buy from us. Further analysis of the returns shows a serious falling off in the textile fabrics, and a considerable rise in machinery devoted to the equipment of foreign manufactories.

Enough has now been said to prove conclusively that, with the exception of the Colonies, our export trade is not only declining in volume, but is at the same time becoming less profitable owing to the change in its character. Advocates of "free trade" do not like the analysis of figures in this way. They much prefer to lump them together, and then to say that the situation is satisfactory, taking everything into account. But, unfortunately, it generally happens that everything is not so taken into account. One important factor usually omitted is consideration of the diminishing value of manufactured exports per head of the population. Another favourite device is to add together exports and imports, and then to point to the sum-total as if it constituted convincing proof of increasing prosperity. That this method of dealing with figures is entirely wrong we hope to demonstrate in a succeeding article, in which attention will be devoted to the source and character of the goods imported into the United Kingdom.

Superheated Steam.

THE comparatively recent revival of superheating in connection with steam engines continues to attract considerable attention, and as the economy resulting from this practice is thoroughly admitted, various firms of manufacturing engineers are devoting their energies to the perfection of superheating apparatus. In a paper recently read before the Institution of Naval Architects, Prof. Watkinson, of Glasgow, described some new types of superheaters designed by him, and discussed the objects and advantages of superheating the steam supplied to engines.

The main problem before engineers from the earliest days of steam engineering has been to diminish the condensation of steam within the engine cylinders, which in a modern engine represents from 12 per cent. to 30 per cent. of the total steam supplied. Of the various devices tried for the reduction of initial cylinder condensation, superheating is by far the most effective at the disposal of the engineer, and it is practically the only method by which initial condensation can be entirely prevented.

The advantages of superheating were recognised at an early date by Boulton and Watt, and in 1859 John Penn made a somewhat extensive use of superheated steam; but the system lived for a very short time. Prof. Watkinson ascribes its premature abandonment to the fact that the attention of engineers was turned to the introduction of higher pressures and to the development of the compound engine. One of our contemporaries, in taking exception to this view, expresses the belief that the real cause was the short life of the superheater itself. Of these explanations we think that of Prof. Watkinson is by far the more probable, but neither of them mentions the further contributing cause, of injury to the engine itself in the form of scored cylinders and valve faces, owing to defective lubrication. Tallow, which was the best lubricant available at the period in question, decomposed at temperatures less than that of the superheated steam, and the charred residue was worse than useless for the purpose of lubrication. No difficulty of the kind exists in the present day, as lubricants are readily obtainable with a flash point of 790 degs. Fahr., a temperature much higher than the mean temperature of

the cylinder walls, and no trouble is experienced in maintaining efficient lubrication.

The suggestion that the brief life of the superheater in former days is to be ascribed to corrosion of the superheater tubes does not appear to be quite satisfactory. It is more probable that the trouble arose from scale, caused by the use of salt feed-water, with consequent burning-out of the tubes. This happened before the introduction of the surface condenser, and there is no reason for supposing that the life of a modern superheater need be shorter than that of a steam boiler.

As we have now reached the limit of efficiency with saturated steam, superheating constitutes the only known means of effecting further economies. An incidental advantage of some importance following the employment of superheating is the reduced demand for steam from the boilers, thus increasing their efficiency as well as that of the engines. In condensing engines further benefit is derived from the reduced amount of work required from air, feed, and circulating pumps. Investigation has proved that hot water will leak far more readily than steam through cracks, and past pistons and valves. Messrs. Callender and Nicholson and Prof. Perry agree in saying that the existence of water round pistons and valves conduces to leakage some 50 times the amount of the steam leak. By the employment of superheated steam most of this leakage is prevented, as well as leakage at steam-pipe and other joints.

Prof. Watkinson considers that in large engines of the usual types it is not advisable to superheat the steam by more than 200 degs. Fahr., and in some cases he says there is trouble with the valves if the degree of superheat exceeds 150 degs. Fahr. He very properly makes an exception in the case of engines fitted with piston-valves, as these permit the limit to be considerably exceeded without difficulty, and with a corresponding gain in efficiency.

As a matter of fact, given a suitable form of design, there is no difficulty in using steam at a temperature of 660 degs. Fahr. or more in the cylinders of an engine. The successful history of the Schmidt system is sufficient proof of this statement. Within the lower limits of superheating mentioned by Prof. Watkinson, the steam cannot be dry throughout the stroke, as in most cases it loses superheat at or about the point of cut off; and in order to obtain the full advantage in compound or triple-expansion engines the steam should be superheated between each stage of expansion as well as before its initial admission.

Leaving the further points discussed in the paper to which we have referred, we will now turn to the results of some experiments recently made by Prof. Watkinson. The object of these tests, which were conducted at the works of Messrs. Mechan & Sons, Glasgow, was to determine the gain in power to be obtained from the application of a superheater to a boiler of given dimensions, and also to determine the saving in steam and coal due to superheating.

The boiler used was of the Lancashire type, 8 ft. diameter and 30 ft. long, and the superheater was one of Watkinson's shunt-circuit type. The rate of combustion was arranged so as to be practically the same in each test. Feed-water was heated by exhaust steam from the engines, and steam for the feed-pump was taken from the same boiler, but was not superheated. The steam generated by the boiler was used in driving a compound vertical engine, directly coupled to a dynamo and running at 350 revolutions per minute, and a horizontal compound engine, running at 121 revolutions per minute, operated a dynamo by means of a belt. The valves of both engines were flat slide-valves, and governing was effected by throttle-valves.

The first test, with saturated steam, was commenced at 10.45 p.m. on August 14th, and the second test, with superheated steam, was commenced at 10.45 a.m. on August 15th. None of the plant had been specially prepared for the tests, as it was desired to make the determinations under ordinary working conditions.

As no other boilers in the works were being used at the time the tests were made, it is probable that a considerable amount of steam from the boiler under

test was lost by condensation in the steam mains ordinari y serving other engines and machinery. This would naturally have the effect of reducing the advantages recorded as the result of superheating. In spite of this drawback, however, the gain in power and the savings in coal and steam, as shown in the following table, are in every way satisfactory :—

than the mere prevention of initial condensation. As the specific heat of superheated steam at constant pressure, according to Regnault, equals 0·4805, the amount of heat required for raising the temperature of 1 lb. of steam by 150 degs. Fahr. is 72 B.Th.U., or about 6 per cent. of the heat required to generate 1 lb. of saturated steam, and the increase of volume is about

SUMMARY OF RESULTS.

—	Test No. 1. Saturated.	Test No. 2. Superheated.
Duration of test	7 hrs. 15 mins.	7 hrs. 5 mins.
Grate area of boiler	42·25 sq. ft.	42·25 sq. ft.
Coal stoked per hr.	1,324 lbs.	1,313 lbs.
,, ,, per sq. ft. of grate	31·4 ,,	31·1 ,,
Weight of combustible, per hr.	1,197 ,,	1,181 ,,
Weight of feed-water, per hr.	7,923 ,,	7,643 ,,
Temperature of feed-water, average	195° Fahr.	197° Fahr.
Pressure of steam, average	98 lbs.	103 lbs.
Temperature corresponding to pressure	336·5° Fahr.	339° Fahr.
,, of steam leaving superheater, average	—	492·5° ,,
,, ,, at engines, average...	331° Fahr.	470° ,,
Degree of superheat at superheater	—	153·5° ,,
,, ,, engines	—	131° ,,
Length of steam pipe between superheater and engines...	87 ft.	87 ft.
Water evaporated per lb. of coal stoked	5·95 lbs.	5·82 lbs.
,, from and at 212° Fahr. per lb. of coal stoked ...	6·31 ,,	6·56 ,,
,, per lb. of combustible	6·61 ,,	6·46 ,,
,, from and at 212° Fahr. per lb. of combustible ...	6·97 ,,	7·30 ,,
Heat utilised per lb. of combustible (assuming steam leaving the boiler to be dry) in B.Th.U.	6,753	7,069
Electrical h.p. during test, average	176·2	240·8
Gain in power due to superheating	—	36·6%
Consumption of steam per electrical h.p.-hrs.	44·9 lbs.	31·7 lbs.
,, coal ,, ,, ...	7·51 ,,	5·45 ,,
Saving in steam due to superheating	—	29·3%
,, coal ,, ,, ...	—	27·4%

The most noteworthy features in these records are the gain of 36·6 per cent. in power and the saving of 27·4 per cent. in coal. Another satisfactory point is that the loss in temperature between the superheater and the engines during these tests was only 22·5 degs. Fahr. As the length of steam pipe was 87 ft., the loss was at a rate of less than 1 deg. Fahr. per yd. of pipe.

It is highly probable that the saving of steam—29·3 per cent.—is considerably greater than the amount of initial cylinder condensation. This is by no means an unusual result in tests of the kind, and it points to the fact that the advantage of superheated steam is due to other causes

30 per cent. It is reasonable to suppose that this increase of volume may exercise an important influence in the degree of economy attained, but in the present state of our knowledge a full explanation is not possible of the phenomena observed during tests of engines with superheated steam.

The Greatest Available Service of Power in the World.

Only a short time ago South Africa was little more than a name to most people in Great Britain. The recent war has

certainly done something in the way of promoting geographical knowledge, but a great deal remains to be learned, especially with regard to the splendid heritage which the Empire owes to the far-seeing sagacity and enterprise of the late Cecil Rhodes. Continental commentators find pleasure in speaking of Britain as an "island kingdom," shutting their eyes to the immense resources and possibilities that are vested in other possessions forming integral parts of Greater Britain.

Americans are by no means in the same state of self-inflicted blindness, for they are particularly alive to the fact that British possessions afford excellent openings for remunerative trading; but they are not very ready to admit that any other country can approach "the States" either in greatness or in natural advantages. Niagara Falls still hold their place in the popular imagination, as the greatest among the wonders of the world, and the curious thing is that while these cataracts are frequently looked upon as if they were in some way the result of American cleverness, no corresponding credit is given to Canada for her share in the same natural feature. It is singularly characteristic of our inherent modesty that Niagara Falls have been allowed to be described and regarded as an American rather than as a British show-place. No similar mistake can be made with regard to the Victoria Falls on the Zambesi River in South Africa —a cataract situated entirely within British territory, and admitted to be the most magnificent waterfall in the world.

Described in the native language as Mosisa-tunya—"smoke sounds there"—this cataract is bounded on three sides by lofty ridges, which, together with numerous islands scattered over the river, are thickly covered with luxuriant vegetation. The falls are caused by a gigantic rent, extending across the river, in the basaltic rock which forms the bed. The cleft in the rock is upwards of 400 ft. in depth, and nearly a mile in length. Into this chasm, more than two-and-a-half times the depth of Niagara, the river plunges with a thunderous roar, sending aloft columns of spray that may be seen for a distance of 20 miles. Immediately below the falls the flow of the river is checked by a rocky wall, the only outlet being a narrow channel cut through this barrier.

Interesting as the Victoria Falls may be to the sightseer, they possess still greater interest from an engineering point of view. The total energy running to waste has been estimated by Mr. Francis Fox at 35,000,000 h.p., and even allowing for a great reduction in the dry season, the available source of power is practically illimitable. Compared with the available capacity of 7,000,000 h.p. at Niagara, the Victoria Falls stand forward as the

Greatest Available Source of Energy

in the world, and it is satisfactory to learn that steps are being taken by the African Concessions Syndicate for the purpose of preparing for the establishment of a power-station on the Zambesi River. Before anything can be done the site must be carefully surveyed, and it is estimated that the total expenses in this direction will amount to about £10,000. The Trunk Railway is now completed to within 70 mls. of the falls, and before next March it should have reached that point, when the surveying expedition will be sent forward. On completion of the survey the details of the power-scheme will be arranged, and the Power Company will be incorporated.

Large markets for power are, of course, necessary for the purpose of making the proposed company a commercial success, and it is fortunate that the main essentials exist in the shape of a fertile and well-watered country, possessing an excellent climate, and in every way suitable for the growth of a white population. Those who are well acquainted with the country speak of it as one that, within a reasonable radius of the falls, is more richly endowed than any other equal area of the earth's surface with minerals, and more particularly with gold, copper, iron and coal. These features inevitably mean a vast increase of population, and the creation of important industries, which will afford scope for the operations of the Power Company. The existing Rhodesian railways will probably be large consumers of energy,

and the various gold-mining centres should take a considerable amount of power.

It should be remembered that the gold-mining industry of Rhodesia is in a most satisfactory condition, and that the output has reached the total of 23,000 ozs. monthly. The gold-mining future of Rhodesia will probably be largely connected with the extensive deposits of low-grade ore, which, as experience in the Rand has shown, is more profitable in the long run than showy patches of highly mineralised reef, and, of course, requires power for suitable working. With regard to copper, it may be mentioned that a belt, 50 mls. wide, has been traced for a distance of 100 mls., some 250 mls. north of Victoria Falls. This will, no doubt, constitute one of the chief copper-fields in the world, and in due time it will inevitably attract a large population, and account for a large consumption of energy. Extensive iron-fields have been discovered close to the falls, and the working of these will give rise to a very considerable demand for power. Moreover, as at Niagara, various manufacturing industries are sure to be established near the central source of power, and these will constitute an important market for electrical energy.

But the possibilities of the proposed power-station are still greater, for by the long-distance transmission of power, various other districts of South Africa could be supplied with current. Long-distance transmission is yet in its infancy. We already have examples in which current is being delivered at points nearly 300 mls. from the generating plant; but it is probable that a transmission of 600 mls. could be accomplished if the need were to arise, as it certainly will after the Victoria Falls Power Station has been inaugurated. A transmission system of 300 mls. would cover the Wankie coal fields, Bulawayo, the Gwelo, Sebakwe, Selukwe, Lomagunda, and Hartley gold-fields, the newly-discovered Northern copperfields, and nearly 1,000 mls. of railways. The various goldfields mentioned have been discovered and opened up within a period of ten years over a tract of country about the size of Central Europe, but with a population of a few thousands; and it is not difficult to imagine what will happen when millions are at work instead of thousands. A transmission system of 600 mls. radius would include the whole of the goldfields of South Africa and an enormous proportion of its railways. The area covered would be inclusive of all Rhodesia, Bechuanaland, and the Transvaal, as well as the greater part of Portuguese Mozambique, German South-West Africa, Portuguese West Africa, and the Congo.

The ultimate development of the scheme is so enormous that it is somewhat difficult to grasp its probable future. The project will require the expenditure of millions, and many years will elapse before it can be fully developed; but the fact remains that, in a country combining great natural advantages, we have a central source of power sufficient for all purposes, and the enterprise stands forth as the most portentous idea that has been conceived in the history of the world.

The Engineering of Illumination.

There is, perhaps, no equally important branch of engineering to-day on which as little study has been given as that of scientific illumination. Its importance is so evident that this state of affairs is rather to be wondered at. It is said that as much as 25 per cent. of all the light used is wasted, and in the majority of cases this waste, which would not be tolerated for an instant in any other department, can be saved by a proper consideration of the exact requirements. The customer gladly pays a round percentage increase for his installation in order to obtain a few per cent. increase in the efficiency of his machinery, but once having obtained the light there is, as a rule, a gross neglect of its utilisation. There has been more or less of an extensive awakening to this peculiar condition, and the work of such men as Mr. W. D'A. Ryan, Dr. Louis Bell, Prof. Wm. L. Smith, and the author of the present paper, shows that the subject is beginning to attract the attention it deserves. Mr. Lansingh's paper was read originally before the Western Society of Engineers, Chicago, of whose Proceedings it forms a portion.

THE question of illumination can be divided into three general classes: (A) street and exterior lighting, (B) interior lighting, (C) decorative and scenic lighting The object of this paper is to point out a few of the underlying principles in interior illumination, with special reference to buildings or rooms of a public or a semi-public character. Before going further, it may be well to examine into the factors constituting good illumination. These can be roughly divided into four classes: (1) Steadiness, (2) Diffusion, (3) Quality, and (4) Distribution.

Steadiness.

Lack of steadiness in an illuminant is at once recognised by everybody as undesirable, and modern sources of light are in this respect very good. With the exception of the open gas flame and arcs of low frequency the illuminants themselves are good, although the wandering of an arc lamp and its constant flickering are often objectionable, even with the best of enclosed arcs. There are cases, however, where the use of a reflector often produces the same effect. Any person who has worked for some time under a swinging incandescent lamp, covered by a porcelain or tin reflector, will have noted the fatigue of the eyes, due to the bright streaks on the paper, which are inherent in the incandescent lamp and intensified by the reflector. In fact, an office so lighted, unless it is superimposed on a good general illumination, is a fine example of something to be avoided, and will quickly ruin all but the strongest eyes.

Diffusion.

Perhaps the first canon of good lighting is to place the illuminant out of the field of vision, or, where this is impossible, to so shade it that its intensity is much reduced. The tendency of modern illuminants has been towards high intrinsic brilliancy, so that the following table in this connection, taken from different authorities, is not only of interest but of much importance in the consideration of good lighting.

TABLE OF INTENSITIES IN CANDLE-POWER PER SQ. IN.

Candle	3 to	4
Oil lamp	3 to	8
Mantle-burner ...	20 to	25
Acetylene	75 to	120
Enclosed arc ..	100 to	200*
Incandescent lamp ...	100 to	300†
Nernst lamp (bare) ...	800 to	1,000
Open arc	10,000 to	100,000
Sun on the horizon ...	2,000	
Sun in zenith ...	190,000	

The three most common illuminants, arcs, incandescents, and mantle-burners, show an intensity so much higher than

* Depending on globe used.
† Depending on efficiency.

that to which the eye has been trained for centuries, that the use of such illuminants without proper diffusion has, to a very large extent, caused the increased use of glasses. It should be noted, however, that the intensity alone is not the only criterion as regards the injurious effect on the eyes. Quantity of light, *i.e.* the intensity multiplied by the area of the illuminant, is extremely important. Thus, although the intensity of the incandescent lamp is very much higher than the ordinary mantle-burner, the effect of the latter on the eyes, unshaded, is perhaps even more injurious than the bare incandescent, owing to the fact that the area of the illuminant is very much larger. The unusual amount of green rays in the mantle-burner also plays some part in this connection. The intensity and quantity, therefore, of modern illuminants are not only much too strong for comfort to the eyes, but when the light is in the field of vision the eye accommodates itself, as far as possible, to the light itself, and is unable to properly judge of objects of less brilliancy. This accounts for the fact that the eye is unable to see past a brilliant light, when it lies in the field of vision. If, however, the light is cut down in intensity by properly diffusing it, the eye can at once see objects beyond the light with comparative ease.

To see how little this important principle is appreciated by the ordinary users of light, one has only to note the glaring examples on any of our streets at night. Here is a shop with a row of bright incandescent lights running up and down, as well as across the windows. The lights may attract attention from a distance, but the goods displayed are at the best but poorly illuminated, as far as the eye can judge. There may be plenty of light thrown on the goods, but the diaphragm of the eye accommodates itself to the brilliancy of the lights, and is therefore unable to properly judge of the goods displayed. Next door there may be a shop where all the lights are concealed, but by proper reflectors the goods are beautifully illuminated, with perhaps one-half the candle-power. The actual illumination on the goods may be considerably less than in the other case, but the eye, not being blinded by the lights themselves, easily accommodates itself to the illuminated goods. One of the worst offenders in this respect is the mantle lamp. A large proportion of those in use are equipped with a little white porcelain fluted reflector, leaving the bare mantle painfully visible. As the candle-power of such burners runs from 50 to 500 or more (cluster lamps) the evil effects of such on the eyes can hardly be over-estimated.

In general it is much better to either place the light out of the field of vision, or when this is impossible to use some sort of a diffusing shade, as the chances are that the illumination, *i.e.* the amount of reflected light falling on the retina of the eye will be greater, for the eye can then work with a larger aperture.

It is also a common mistake to think that the more light one has the better one can see. In fact, there can hardly be a greater error. After the stimulation of the retina amounts to a given quantity, the effect of more light is to contract the iris, producing a strain of the muscles of the eye; further, too much light strains the retina, producing after images and rapidly weakening it through over stimulation. The effect is very much like a photographic plate which has been over-exposed; the picture is blurred and darkened. Moreover, too much light entering the eye, whether direct or

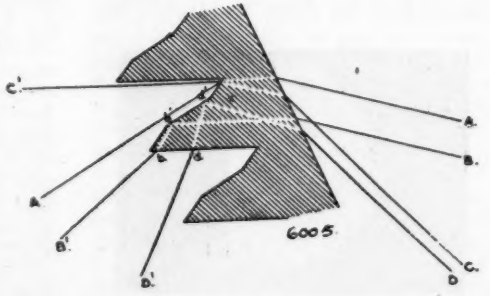


FIG. 1.

indirect, prevents one from properly judging of distances and shadows, without which ability to judge the eye is quickly fatigued.

Where there is insufficient illumination, one of the first phenomena noted is the inability of the eye to judge of colour, everything tending to become a dull grey. The muscles of the eye are strained to keep the diaphragm wide open, while the eye loses its judgment as to shadows and distances. Moreover, the attention of the observer is strained in an attempt to see

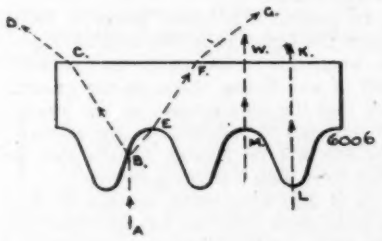


FIG. 2.

properly. The result of too much or too little illumination is in either case apt to be severe and frequent headaches and a final resort to the oculist. It is evident, then, that we must not err upon either side, *i.e.* from over or under stimulation.

It is necessary here to consider briefly certain classes of shades, as these play an important part in laying out any system of lighting. In general, shades can be divided into four classes: (1) decorative, (2) diffusive, (3) directing, (4) diffusing

FIG. 3.

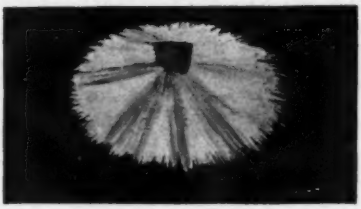


FIG. 4.

and directing. From an engineering standpoint, it is unnecessary here to consider the first class. The second class is extremely important, and there are many kinds on the market which more or less accomplish the work for which they are designed. They all have, however, the objection that they are inefficient, absorbing an amount of light varying from 15 to as high as 60 per cent. The diffusion is often obtained in such shades by colouring matter, and this, as we shall see later, is sometimes highly objectionable. The third class is exemplified by the

FIG. 5.

numerous reflectors on the market. These are, in general, quite efficient as far as concentrating the light in some given direction is concerned, although the actual efficiency, taking into account the spherical distribution, is generally quite low, if the reflector covers a considerable portion of the light. Their chief objection is that they do not diffuse the light, and when used over books, etc., are apt to cast a very strong regular reflection to the eye, which coming as it does from below (the eye is accustomed to have light come from above) produces fatigue very rapidly. An exaggerated case like this is what is

known as "snowblindness." It is due to the fact that the strong reflected light is directed to the upper part of the retina, which not being accustomed to this unwonted stimulation is quickly fatigued.

The fourth class contains such shades as the McCreary, McFadden and Holophane. The first two consist essentially of a reflector with a ground glass bottom, and beautifully accomplish the purpose of throwing a concentrated beam of light without the glare from an ordinary reflector, but at a rather high loss of efficiency, viz : about 34 per cent. For desk lighting these shades are excellent, and much to be preferred to the ordinary green porcelain cone with its intensified streaks and its resultant glare, due largely to regular reflection. The Holophane type of shade is an attempt to obtain both diffusion and direction of the rays of light with minimum absorption. Prof. Wm. L. Smith, who has made extensive tests on these and other globes, reports for electrics a mean loss by absorption of $12\frac{3}{16}$ per cent.

As these globes play an important part in the exact calculation of illumination, it may be well to examine briefly into the principles of the same. They have a series of annular compound prisms on the external surface, a cross section of which is shown in Fig. 1. As will be seen, those rays, the direction of which it is desired to change by but a small amount such as AA', are bent by refraction only. Where, however, it is desired to bend the ray still more, advantage is taken of the principle of total reflection shown in DD'. It will be seen at once that by properly shaping these refracting and reflecting surfaces almost any distribution of light can be obtained.

In order to obtain the diffusion, the inner surface of the globe is made with a series of vertical prisms, an enlarged cross-section of which is shown in Fig. 2. These prisms in general follow the law of cosines, and, as will be seen, split the ray AB into two components, one being simply refracted, while the other is reflected and then refracted. It is evident, however, that such rays as MW and LK, striking at right angles to the surface of the glass, would not be affected, and the glass would consequently consist of a series of bright streaks. As, however, the exterior prisms are at right angles to the interior prisms, these streaks are broken up, producing a somewhat tesselated appearance when closely examined, but in general, unnoticed. The perfect diffusion of these globes is only exceeded by a dense opal shade, while their ability to redirect the rays of light, combined with an absorption factor only slightly higher than clear glass, renders their use in many cases of much value.

Although these globes are made in many shapes, and for all forms of illuminants, they can be in general divided into three classes, depending on the way they distribute the light. These are rather strikingly illustrated in Figs. 3, 4, and 5. Fig. 3 shows a type of globe for downward distribution, such as is used on high ceilings, over desks, tables, etc. Fig. 4 shows a type intended for general distribution, the light being thrown almost equally at all angles below the horizontal. Fig. 5 shows a type in which the light is mostly thrown at an angle of from 10 to 20 degs. below the horizontal, and is especially used for lighting large interiors and street lighting. It is rather interesting to note how closely these pictures are actually substantiated by photometric tests, and Figs. 6, 7, and 8 show the distribution curves of these globes when applied to the Welsbach light. For the sake of comparison, the curve of the unshaded lamp is also shown by a broken line.

As would naturally be supposed, the external horizontal prisms offer a very good place for accumulation of dust, and therefore, unless globes are properly protected, their use outdoors is not to be recommended. In spite of this trouble, the third type of Holophane globes has been used considerably abroad for street lighting. In Munich several thousands have been used on the Welsbach street lamps for several years with extremely good results. As the lights are properly protected by an enclosing lantern, the globes are largely sheltered from the dust. The breakage runs in this installation about

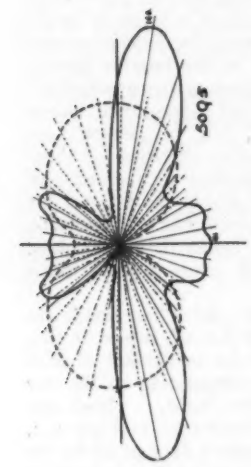


FIG. 8.

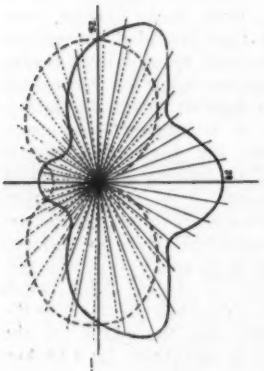


FIG. 7.

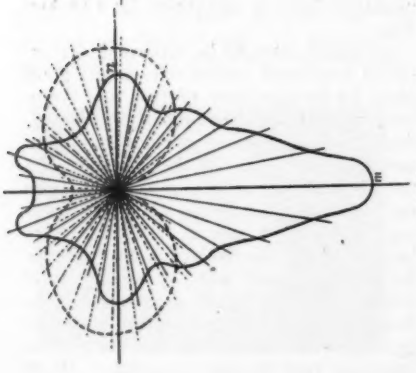


FIG. 6.

Note.—Dashed line denotes Welsbach.
Full " " with Holophone.

10 per cent. per annum. In in-door lighting, where the globes can be given proper attention, their use is very important and enables exact calculations to be made beforehand. As the globes are made of pressed glass, individual globes of the same type are practically uniform, and allow of precision in the determination beforehand of the results to be obtained; such precision being unattainable with ordinary globes of blown glass, which vary widely in thickness of glass, density, and amount of colouring matter. An example of the precision which can be obtained with these globes is the illumination of a church by Prof. Smith. The illumination at 83 points of the church, both on the balconies, on the main floor, and under the balconies, was calculated beforehand, and later measured by an illuminometer. The mean per cent. between the measured and calculated values was $6\frac{8}{10}$, the maximum being $27\frac{3}{10}$, and the minimum 0.0, the higher figures being due to certain lights which were added after the calculations were made. These results show what it is possible to do in the way of exact calculation of illumination.

Quality.

It is well known that modern illuminants vary widely in their proportion of different wave lengths and that consequently the colour effects are very different. We can note here the predominant colour in a few of the most important illuminants:—

Sun at noon—white.
Sun near sunset—reddish.
Enclosed arc, low voltage—white.
Open arc—bluish white to violet.
Nernst lamp—white.
Acetylene—white.
Incandescent electric—yellowish white.
Mantle-burner—white with a tinge of green.
Open-flame gas—orange white.
Kerosene lamp—orange white.
Candle—orange yellow.

The question of colour plays an important part in the study of illumination. For some purpose, where it is desired to produce the effects of daylight as nearly as possible, the arc lamp, when the violet rays are properly filtered out, plays an important part. In general, however, the colour of the arc is cold, and for a room

where the effect is to produce a cheerful and warm appearance, an illuminant with more of the red rays, such as the incandescent lamp or ordinary gas, is very much to be preferred. This is well recognized by billiard experts so that daylight is excluded as far as possible and incandescents, not arcs, are used for illumination, giving a warm and cheerful appearance to the room. Candles and oil lamps also produce this effect, so that for home use they are from this standpoint, as well as from their low intrinsic brilliancy, preferable to mantle-burners or even incandescents.

Recent experiments by Dr. Finsen and others seem to show also that the violet and ultra violet rays are physiologically injurious. If all of these rays are filtered out it has been conclusively shown that smallpox patients are unmarked by the disease. A superabundance of these rays have the effect of destroying bacilli, so that skin diseases and diseases of the tissues are cured by treating the patient to concentrated beams of highly violet and ultra violet rays. Professors Nichols and Hull proved recently by experiment that rays of light are capable of producing pressure and it may be that waves of too high a frequency produce on a delicate tissue too high a concentrated pressure, tending to destroy the same, or at least producing irritation. This would account for the fact that animals as well as persons like the *warm* sunlight or light where the lower part of the spectrum predominates. Thus the harsh effects of brilliant noonday sun, where the waves of higher frequency are not filtered out by the atmosphere are not as pleasant as the warm glow from the setting sun.

Where it is necessary to match colours under an artificial light, too much care cannot be given to the subject of the colour of the light and also of surrounding objects. If, for example, it is desired to match a piece of silk, which is blue in daylight, and the same were done in a room where the light was red, the colour of the silk would appear almost black. This, however, is an extreme case, as almost all illuminants contain more or less of all wave lengths. As the spectra of

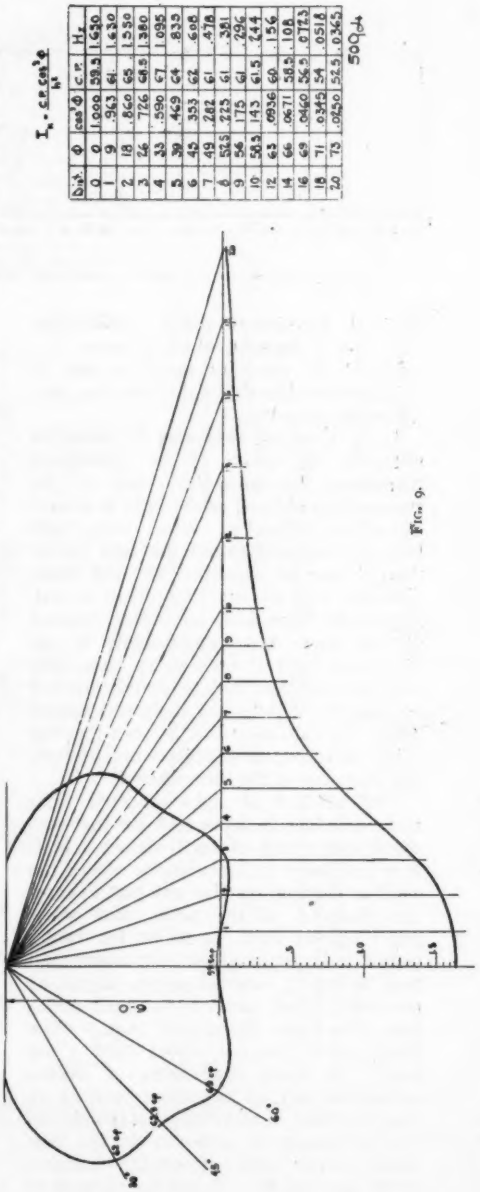


FIG. 9.

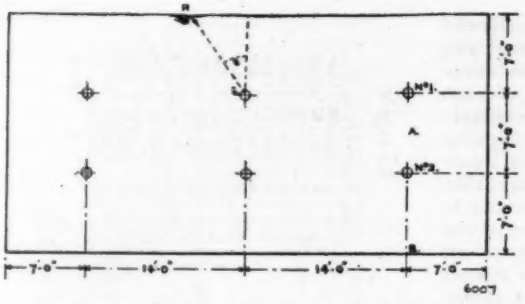


FIG. 10.—SYSTEM OF ILLUMINATING ORDINARILY USED.

artificial illuminants differ considerably from that of daylight, which is taken as a standard, the resultant shade or tints of objects viewed in this light may be considerably altered.

It is, however, necessary to consider not only the colour of the illuminants themselves, but also the colour of the surrounding objects, as the light is materially affected thereby. When white light falls on a red surface, all the rays except the red ones are absorbed, the red being reflected and we say the object is red. Thus light from such an object consists of red rays, and consequently if the illuminant itself is hidden, we have only red rays, and any object in this light, if not capable of reflecting such, will appear black. It can, therefore, be seen that the colour of surrounding objects much affects the character of the illumination.

The amount of light reflected from surfaces is largely dependent on the condition and colour of such surface. It is very necessary in calculations where the walls or decorations play any part to know the character of the same; thus white paper reflects from 70 to 80 per cent.; yellow wall paper gives only about half that amount; emerald green about 18 per cent.; black paper about 5 per cent.; deep blue paper about 3 per cent.; while black velvet gives only about $\frac{4}{10}$ of 1 per cent. As these coefficients of diffuse reflections play an important part, as we shall see later, in all attempts at calculation it is necessary, in order to do the best work, to know rather closely the character of the decorations. A striking example of this was noted by the writer in a club, where one of the main rooms was formerly decorated in light tints. In redecorating, everything was changed to a deep rich red, and while the effect was extremely warm and pleasing, the effective illumination was so cut down, as to make imperative an increase in candle-power of the lamps used. One can note this very strikingly if in a dining-room decorated in rather dark colours the table is covered by a white cloth, the effect being to brighten the room very noticeably.

It can easily be shown that if K is the coefficient of reflection, and the light is reflected from one wall to the other and back again, the illumination as directly calculated should be multiplied by the factor $\frac{1}{1-K}$ showing the relative effect of the walls. If the room is of any considerable size, this factor becomes in many cases practically unity, while if the decorations are light, this factor may rise to 2 or 3 or even higher, depending on the conditions. It is therefore necessary to carefully consider this factor. In the case before mentioned of the calculations of the church, this factor was 75 per cent., and the fact that the mean results only differed about 6 per cent. from the calculations shows how carefully this factor was determined.

Distribution.

The illumination of an object depends on two factors: first, the amount of light falling on the object; and, second, the amount reflected to the retina of the eye. In order to calculate the amount of light falling on any given object, we must first determine the photometric curve of the illuminant used, with its shade or reflector, if such there be. The normal illumination —*i.e.* the illumination upon the plane at right angles to the rays of light—is determined by the laws of inverse squares: $I_N = \frac{C.P.}{d^2}$, where $C.P.$ is the candle-power

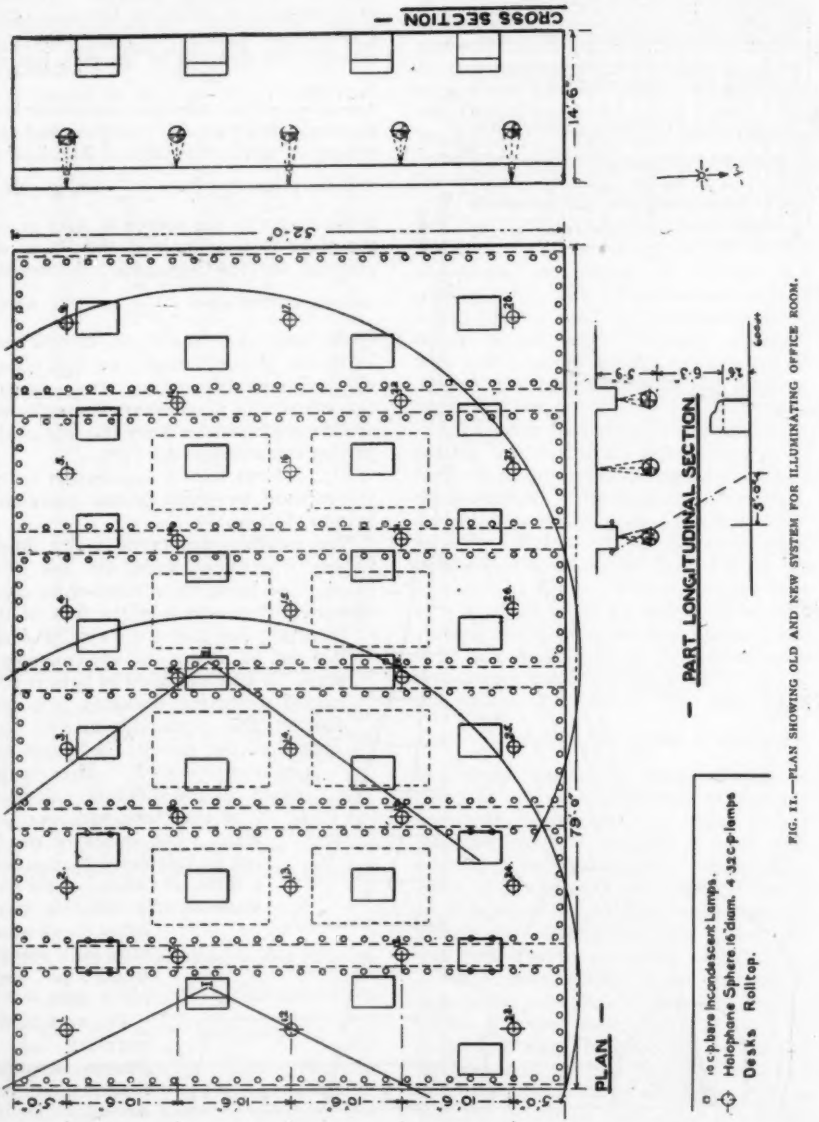


FIG. 11.—PLAN SHOWING OLD AND NEW SYSTEM FOR ILLUMINATING OFFICE ROOM.

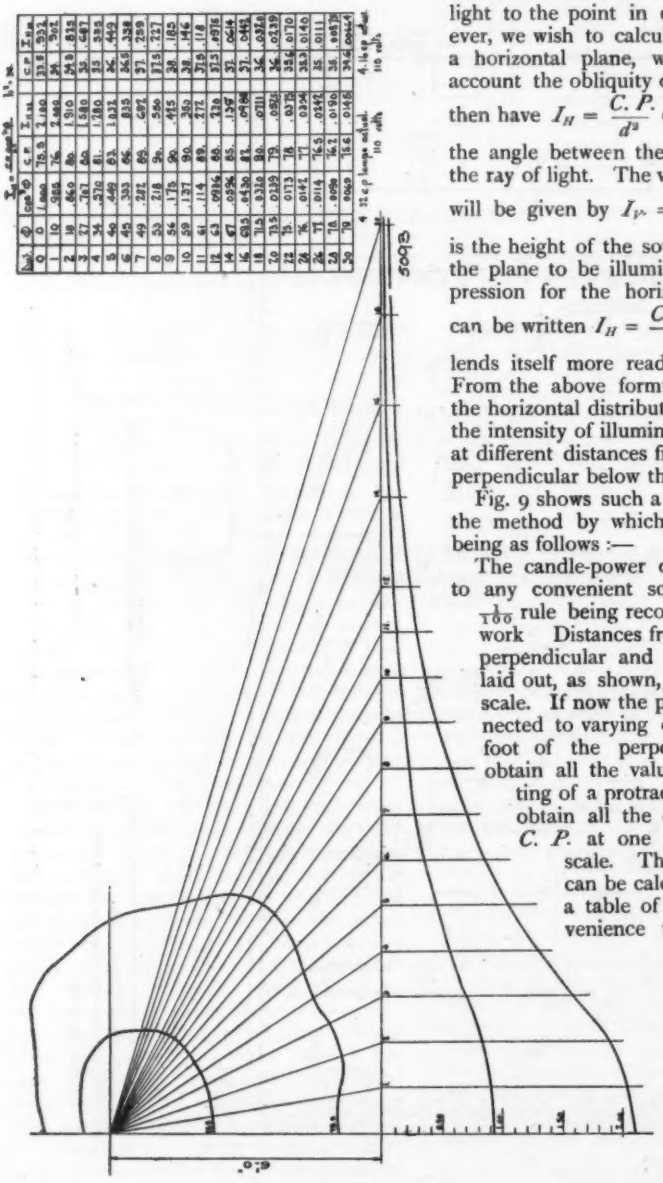


FIG. 12.

and d the distance from the source of light to the point in question. If, however, we wish to calculate the light upon a horizontal plane, we must take into account the obliquity of the rays, and we then have $I_H = \frac{C.P.}{d^2} \cos \phi$, where ϕ is the angle between the perpendicular and the ray of light. The vertical illumination will be given by $I_V = \frac{C.P.}{d^2} \sin \phi$. If h is the height of the source of light above the plane to be illumined, the above expression for the horizontal illumination can be written $I_H = \frac{C.P.}{h^2} \cos^3 \phi$, which lends itself more readily to calculations. From the above formula we can obtain the horizontal distribution curve, showing the intensity of illumination in candle-feet at different distances from the feet of the perpendicular below the light.

Fig. 9 shows such a distribution curve, the method by which it was calculated being as follows :—

The candle-power curve is first drawn to any convenient scale, the use of a $\frac{1}{100}$ rule being recommended for rapid work Distances from the foot of the perpendicular and the value of h are laid out, as shown, to any convenient scale. If now the point of light is connected to varying distances from the foot of the perpendicular, we can obtain all the values of ϕ by one setting of a protractor. We can also obtain all the different values of $C.P.$ at one time with our $\frac{1}{100}$ scale. The values of $\cos^3 \phi$ can be calculated by means of a table of cubes, but for convenience the table is given below for all whole angles, which would be ordinarily used.

The work hardly permits of a greater accuracy than $\frac{1}{2}$ deg., and the values for $\cos^3 \phi$ for $\frac{1}{2}$ degs. can be obtained from

the table by interpolation. We can then obtain the values of I_H by means of slide-rule. Except in rare cases, it is not necessary to carry the table further than a value of I_H, equal to 2 per cent. of the maximum value.

$\phi°$	$\cos^3\phi$	$\phi°$	$\cos^3\phi$	$\phi°$	$\cos^3\phi$
1	1·000	29	·668	57	·161
2	·998	30	·649	58	·149
3	·998	31	·630	59	·137
4	·993	32	·610	60	·125
5	·988	33	·590	61	·114
6	·983	34	·570	62	·103
7	·978	35	·550	63	·0936
8	·971	30	·529	64	·0842
9	·963	37	·509	65	·0754
10	·955	38	·489	66	·0671
11	·945	39	·469	67	·0596
12	·935	40	·449	68	·0526
13	·925	41	·429	69	·0460
14	·913	42	·410	70	·0400
15	·901	43	·391	71	·0345
16	888	44	·372	72	·0295
17	·874	45	·353	73	·0250
18	·860	46	·335	74	0209
19	·845	47	·317	75	·0173
20	·829	48	·300	76	·0142
21	·813	49	·282	77	·0111
22	·797	50	·265	78	·00900
23	·780	51	·249	79	·00695
24	·762	52	·233	80	·00523
25	·744	53	·218	81	00383
26	·726	54	·203	82	·00270
27	·707	55	·189	83	·00181
28	·688	56	·175	84	·00114

In practice it is found easier to use the table for calculating the illumination rather than the curve, the principal value of the curve being to show graphically the variation of the illumination. It is possible to use the same curve for any value of h; thus if it is desired to use a new height h' we can obtain the corresponding value of I_H as follows: We have at once $\frac{h}{h'}=\frac{d}{d'}$ whence $d=\frac{h}{h'}d'$. Looking in our table we obtain the value of I_H corresponding to d, and this value multiplied by $(\frac{h}{h'})^2$ gives the new value $I_{H'}$. This process in practice is very simple, and new tables for different values of h can be obtained this way, or, if desired, the same way the original table was calculated.

If the illumination is projected upon the horizontal or some other plane it is possible to obtain the resultant illumination from a mesh-work of lights by adding the separate illuminations arithmetically, and we can therefore obtain the resultant illumination, due allowance being made for the reflection from surrounding objects. In large places, where the walls are at considerable distances, this reflection factor can often be neglected.

In street lighting it is customary to use not the horizontal but the normal distribution of light, and although this has its objections in general it answers the purpose fairly well. For interiors, such as stores, offices, etc., the horizontal distribution is the most important, although with stores, where goods are displayed on shelves, the vertical distribution plays an important part.

In lighting picture galleries and similar places, the horizontal distribution is of little value, the vertical being the important consideration. The formula before given for vertical distribution does not hold, however, except for a plane at right angles to the source of light. Thus, for example, in Fig. 10, showing a plan view of a room in which we wish to obtain the vertical distribution, the formula does not hold true for the ray R S, and we must take into account the angle at which the ray strikes the wall. We then have $I_V=\frac{C.\ P.}{h^2}\cos^2\phi\ \sin\ \phi\ \cos\ \phi$ where ϕ is the angle between the perpendicular to the wall and the projection of the ray upon the horizontal. In order to use this, we can first consider a table with $\phi=o$ and then multiply the corresponding value of I_V by different values of $\cos\phi$. In this way it is possible to calculate the illumination falling normally upon the wall from a given mesh-work of lights.

Before going further, it may be well to note some examples of bad distribution. Given a room shown in Fig. 10, it is customary with architects to lay out the lighting as shown. If the lights used had the distribution curve shown in Fig. 9, with the height as there given, we would obtain a value at the point A from the lights 1 and 2 of 2·48 candle-feet. At B

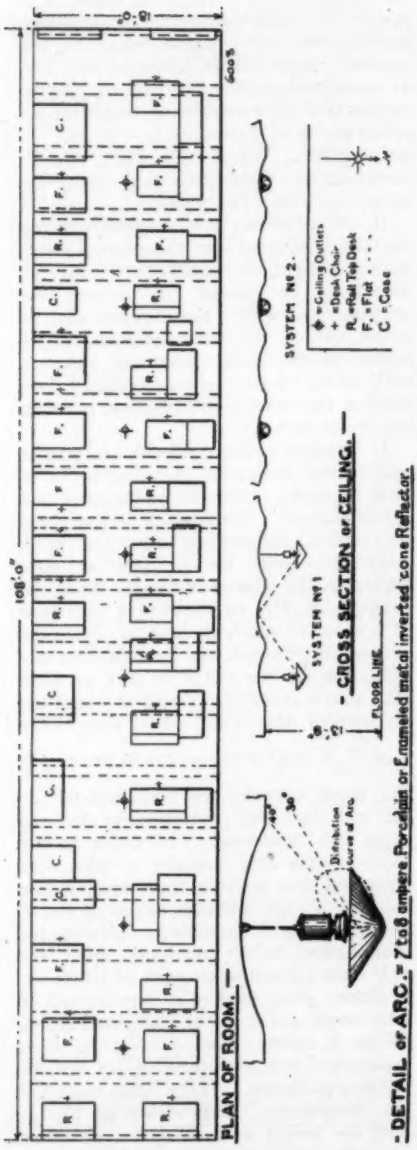


FIG. 13.—PLAN OF ILLUMINATION FOR LARGE BUSINESS ROOM.

we would obtain a value of 0·602 candle-foot. We thus see that there is a great variation in the horizontal illumination at these points. This would be somewhat offset, however, by the reflection from the walls, ceiling and decoration of the room. It must be noted, however, that an even distribution of illumination must often be sacrificed to artistic effect, and in the case above considered it would not be advisable to place the lights nearer than 5 ft. to the walls, although 4 ft. would give an illumination at point *A* of 1·16 candle-feet. Illumination is not, therefore, merely an engineering problem, as the artistic and esthetic results must always be borne in mind.

In order to bring out the foregoing principles more clearly we will take, for example, the lighting of a large office room. The plan and elevations of this room are shown in Fig. 11, which shows both the old and new systems of lighting. The former used bare 10-candle-power incandescent lights, placed on the beams as shown. The decorations of the room are dark green, the floor of red and white rubber squares, and the furniture and woodwork mahogany. It was therefore impossible to allow very much for reflection, especially as a large part of the walls and ceiling was occupied by windows and large skylights shown by dotted lines in the plan, which gave a good light during the day. The effect of all these bare incandescent lamps on the eyes was extremely hard. A person working at one of the desks at the west end would catch the full glare of these lamps from one side of the beam every time he glanced up, and as no desk lights were used, the strain was extremely disagreeable, while at the same time the amount of illumination was not sufficient for comfortable work, the maximum amount falling on a desk being 1·21 candle-feet. One of the first things noted about this system was that all the lights on the far side of the beam were practically useless for lighting the desks on the near side, as is shown in the longitudinal section, where it is evident that all such lamps throw no direct illumination at a point 5 ft. from the edge of the beam and that,

therefore, a large percentage of the light was useless. It should also be noted that roll-top desks were used, and that consequently a good deal of the light was cut off by the tops, and as the reflection from the walls was small this light also was practically useless. This is shown by the straight lines drawn from desks No. 1 and No. 2, which show that all the lights on the near side of the beam within the angle enclosed by the two lines are useless, as far as direct illumination on the desk in question is concerned. This applies, however, not only to the old but the new system of lighting. Provided flat-top desks were used the increase in illumination would be considerable. A study of the distribution curves actually used shows that the summation of all the illumination received from the light beyond a radius of 35 ft. is negligible.

It is apparent at once, in calculating the useful illumination in a situation like this, that it is necessary to use the horizontal rather than the normal. Fig. 12 shows the photometric and horizontal distribution curves actually used. It was decided in this case, after drawing a number of plans, to instal 16-in. Holophane spheres enclosing four 32-candle-power lamps The wires, being brought down the chain, were practically invisible, and the same could be finished to be in keeping with the decorations of the room. By the use of four 32-candle-power lamps in each of the twenty-eight spheres used, a considerable reduction in the current was obtained. Formerly there were 414 10 candle-power lamps, making a total of 4,410 candle-power, while with the new method there is 3,584 candle-power, being a saving of 13½ per cent. In addition to this, the 32-candle-power lamps being of an efficiency slightly higher than 3½ watts per candle, while the 10-candle-power lamps are about 4 watts per candle, there resulted an additional saving of at least 14 per cent. The height of these spheres was governed by the artistic conditions.

The illumination obtained on the desks under the old system of lighting was first calculated, taking the sum of the illumination of all lamps, and without considering the fact that the person sitting at the desk would cut off a certain amount of light; this gave a resultant illumination on desk No. 1 of 1·17 candle-feet, and on desk No. 2 of 1·21 candle-feet. The new system was then calculated in the same manner, giving an illumination of 2·60 candle-feet on desk No. 1, and 2·98 candle-feet on desk No. 2. It is evident, however, that a number of the lights in each case are useless for direct illumination, owing to the fact that a person sitting at a desk will cut off some of the light. This results in more or less shadow, the intensity of which is an extremely important point in desk lighting. The ratio of the effective to the total illumination will give us an idea of the intensity of such shadows, and if they exceed 20 per cent. they become annoying. Another important point to be considered is the effect of the shadows cast by the hand in writing. For example, on desk No. 1 lights 1, 2, 3, 7, and 8 cast shadows if the person is writing with the right hand, while the light on the other side will not cast these shadows. Desk No. 1, however, is one of the worst cases of this kind. If one considers desk No. 3, the intensity of these shadows will be much reduced as the principal illumination is coming from light No. 20. In order to avoid, however, these conditions entirely it would be necessary to use desk lights, which in the present case was not desired. The location of the lights was governed by two conditions: first, the fact that the panelled ceiling required for the artistic effect that the lights be placed either in the centre of each panel or on the beams, and this was still further narrowed by the fact that skylights, shown on the plan, made it practically impossible to place any lights under them. The second condition was the fact that an even distribution of light was wanted over the entire room, as the desks were liable to be shifted at any time. The location of the lights, taking these factors into account, was finally obtained as shown, although several other different arrangements were tried. The effect of these was not as good as that finally adopted.

One more example of desk lighting may bring out the principles even more clearly.

Fig. 13 shows the plan of a room used for engineering purposes. The lights as originally installed consisted of eight clusters of six 32-candle-power lamps, each under mirrored reflectors, dropped about 1 ft. from the ceiling. The effect of these bare lights was extremely trying to the eyes; while, owing to the fact that most of the desks had roll-tops, on which were cases for books, etc., a large amount of the light was useless, as far as direct illumination was concerned, and the shadows cast were very trying. These conditions, however, were somewhat helped out by the fact that the ceiling and walls were white plaster, and a good deal of indirect illumination was obtained. As, however, the north side of the room was almost entirely of factory ribbed glass, and the other side had a row of glass windows opening on to a hall, this indirect illumination was not sufficient to offset the advantages of the system used. It was desired, if possible, to obtain sufficient illumination without the use of desk lights, and a number of plans were tried. In every case, however, the calculations showed that, owing to the arrangement of the desks, the shadows cast would be strong, which finally brought the problem down to one of two propositions. Fig. 13, plan 1, shows a system of indirect illumination by the use of inverted arcs. Most of the light is thrown directly upon the ceiling, while the inverted reflector prevents the light from coming down, and throws it back to the ceiling. The candle-power curve of such an arc is shown dotted, and it will be noticed that the maximum is from 30 to 40 degs. above the horizontal. The height of the arcs was calculated, so that the zones of maximum intensity did not overlap on the ceiling. Taking into account the normal distribution, this gave a very even light over the ceiling and high side walls. This plan was abandoned, however, owing to its inefficiency. In the first place, the room was located in a large factory, where there was a great deal of dirt, the ceiling and walls becoming rapidly coated with dust, which would necessitate frequent cleaning and also whitening the walls several times a year. Even under the best conditions, it was improbable that an efficiency of more than 50 per cent. could be obtained, while frequent trimming of the lamps, owing to the fact that they were inverted, made the cost of maintenance high. Further, as the desks on the south side had to be lighted by artificial light a good part of the day, it would be necessary, under this scheme of indirect illumination, to burn all the lights all day long, while under the plan with desk lights, finally adopted, only the south lights need be used during the day, resulting in a large saving of current.

(To be concluded.)

ENGINEERING ABSTRACTS.

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MATERIALS AND MEASUREMENTS.

The Influence of Variations in Water and Sand on Cement.

THE personal equation cannot be removed in testing cement, but other conditions that vitally affect the results can be brought to a uniform basis, and these may be briefly summed upas—(1) the quantity of water used to produce a mortar of given consistency, (2) the time and manner of manipulation, (3) the method of moulding, (4) the temperature of the water and air, (5) the time and conditions of exposure in air and water, and (6) the rate of applying the load. The writer was led to make a series of tests on these lines in somewhat more detail than anything he had seen published. In the tensile results, the Portland cement series mixed neat, showed rapid and uniform improvement between 24 hours and 7 days, but the drier mixtures generally held their superiority. This was noticeably uniform in the Atlas cement at all periods. The maximum strength was attained at three months, after which, and up to one year, there appeared a steady falling off in strength, but from three months on the drier mixtures were uniformly better. The Giant cement also attained its maximum strength at three months, at which period the drier mixtures also appeared uniformly superior, with the exception of the 15 per cent. series, and, judging from the results of this series throughout the test, it would appear that there was not quite enough water to perfect the crystalisation of the cement. The Giant cement showed a falling off between three and six months, but a good recovery after this latter period in all but the 22 per cent. series. The wettest mixture, 24 per cent., passed the three series next below at one year, two of them, in fact, at six months, and between six months and one year it showed a more rapid gain than any of the other series. The personal equation was apparent in these tests, but every effort was made to secure consistent and uniform results. A tabulation is added showing the tensile strength of Portland cement mortars in the proportion of two parts sand to one cement. A silicious sand was selected for this test, carefully screened to the sizes noted, and combined in the proportions given in the table. The test was made to determine the relative value of sand-grains of different diameters, in combination with cement, and also to study the effect upon the tensile results of adding fine material.—**E. S. Larned,** *Amer. Soc. Testg. Materials, Rept. Eng. Rec., Vol. XLVIII., No. 10.*, pp. 273–276.

TENSILE STRENGTH OF CEMENT MORTAR WITH SAND GRAINS OF DIFFERENT DIAMETERS. RESULTS GIVEN ARE THE AVERAGE OF SIX BRIQUETTES.

Sand Gauge. Per Cent. used.				Portland Mortar, 2 to 1.			
					Giant.		
No. 30.	No. 20.	No. 100.	Fine.	Water per cent.	7 days.	28 days.	6 mos.
100	...	...	...	10½	286	288	412
...	100	...	...	10½	294	331	473
...	...	100	...	10½	201	226	294
...	...	...	100	10½	129	159	223
80	10	10	...	10½	361	380	486
70	15	12½	2½	10½	301	303	428
60	20	15	5	10½	307	311	419
50	25	17½	7½	10½	391	400	538
40	30	20	10	10½	350	355	475
30	25	30	15	10½	362	359	478
20	20	40	20	10½	317	374	480
10	15	50	25	10½	291	354	488
50	...	...	50	10½	247	287	351
50	50	...	...	10½	440	408	542
50	...	50	...	10½	309	336	438
25	25	25	25	10½	279	337	447
Crushed Quartz.							3 mos.
40	...	60	.	9½	257	331	351

MEMO.—All proportions and percentages determined by weight. Natural sand used; first passed through No. 8 screen and residue excluded; No. 30 sand passed No. 20 screen and caught on No. 30 screen; No. 20 sand passed No. 8 screen and caught on No. 20 screen; No. 100 sand passed No. 30 screen and caught on No. 100 screen. "Fine" is clean white sand sifted through the No. 100 screen.

Standard Specification for Portland Cement.

THE committee appointed by the Canadian Society of Civil Engineers to consider standard Portland cement tests recommend the following specification. The whole of the cement is to be well-burned pure Portland cement of the best quality, free from free lime, slag, dust, or other foreign material. (1) *Fineness.*—The cement shall be ground so fine that the residue on a sieve of 10,000 meshes to the square inch shall not exceed 10 per cent. of the whole by weight, and the whole of the cement shall pass a sieve of 2,500 meshes to the square inch. (2) *Specific gravity.*—The sp. gr. of the cement shall be at least 3·09, and shall not exceed 3·28 for fresh cement, the term "fresh" being understood to apply to such cements as are not more than two months old. (3) *Tests.*—The cement shall be subjected to the following tests:—(*a*) *Blowing test.*—Mortar pats of neat cement shall be trowelled upon 5 ins. by 2½ ins. ground-glass plates. The pats shall be about ½ in. thick in the centre, and worked off to the sharp edges at the four sides. They shall be covered with a damp cloth, and allowed to remain in the air until set, after which they shall be placed in vapour in a tank, in which the water is heated to a temperature of 130 degs. Fahr. After remaining in the vapour six hours, including the time of setting in air, they shall be immersed in the hot water, and allowed to remain there for eighteen hours. After removal from the water the samples shall not be curled up, shall not have fine hair cracks nor large expansion cracks, nor shall they be distorted. If separated from the glass, the samples shall break with a sharp crisp ring. (*b*) *Tensile stress.* — Neat cement: Briquettes, mixed with about 20 per cent. of water by weight, after

remaining one day in a moist atmosphere, shall be immersed in water and shall be capable of sustaining a tensile stress of 250 lbs. per sq. in. after submersion for 2 days, 400 lbs. per sq. in. after submersion for 6 days, 500 lbs. per sq. in. after submersion for 27 days. The tensile test shall be considered as the average of five briquettes, and any cement showing a decrease in strength on or before the 28th day shall be rejected. *Sand and cement.*—The sand for standard tests shall be clean quartz, crushed so as to pass through a sieve of 400 meshes to the sq. in., but shall be retained on a sieve of 900 meshes per sq. in. The sand and cement shall be thoroughly mixed dry, and then about 10 per cent. of their weight of water shall be added, when the briquettes are to be formed in suitable moulds. After remaining in a damp chamber for 24 hours the briquettes shall be immersed in water. Briquettes made in the proportion of 1:3 by weight, shall bear a tensile stress of 125 lbs. per sq. in. after submersion for six days, and 200 lbs. per sq. in. after submersion for 28 days. Briquettes shall not show a decrease in tensile strength at the end of 28 days, or subsequently. (4) The manufacturer shall, if required, supply chemical analyses of the cement. (5) *Packing.*—The cement shall be packed either in air- and water-tight casks, lined with brown paper, or in air- and water-tight bags. (6) The manufacturer shall give a certificate with each shipment of cement, stating (i.) the date of manufacture; (ii.) the tests and analyses obtained for the cement in question at the manufacturer's laboratory; (iii.) that the cement does not contain any adulteration.—*Rept. Quarry, Vol. VIII., No. 93*, pp. 547–550.

Manufacture and Properties of Hydrate of Lime.

THERE are two distinct forms of lime—the rich lime high in calcium and the magnesium lime burned from dolomite. The principal defects in both forms can be summed up as follows: (1) They deteriorate rapidly; (2) they cannot be kept in packages for any length of time; (3) they are dangerous to store on account of fire; (4) they require manipulation before using—*i.e.* slacking, screening, ageing; (5) they invariably contain small particles which swell after being on the wall for a few months, and spoil decorations; (6) they cannot be transported safely by water; (7) they are difficult and dirty to handle. Proper hydration does away with every one of these defects without impairing the usefulness of the lime. Probably the greatest future of hydrate of lime lies in its use with Portland cement. The most successful method of manufacturing hydrate in this country is as follows: The lump lime as it comes from the kilns is finely ground and passed over a 26-mesh wire screen. It is then elevated, and passed into a digester, and treated with water at a certain temperature, the two being handled in such a way that the lime cannot possibly burn. This mixture is then cooled and screened, and all particles not thoroughly hydrated are taken out. The powder is then put up in paper and jute sacks, and can be kept. The effect of adding a little hydrate to Portland cement is somewhat astonishing. Careful tests show that a mixture of cement 1, hydrate ¼, sand 4, is nearly one-half stronger than cement 1, sand 4, without lime. Nearly equal results are given with cement 1, lime ¼, sand 5, and cement 1, lime ⅓, sand 5. Tests were made showing that cement 1, sand 4 showed 260 lbs. at seven days, while cement 1, lime ¼, and sand 4 showed 340 lbs. On the other hand, the addition of a little Portland cement to a large amount of hydrate does not show gratifying results. It is thought that a mixture of ⅔ hydrate of lime, ⅓ cement, and 3 or more parts of sand would make, with the addition of hair, an excellent hard-wall plaster. Great care should be used when mixing with cement to use a hydrate entirely free from core or unslaked lime, a little of which would produce disastrous results by swelling. The actual expense of reducing ground quicklime to a hydrate is about 25 cents. per ton. The increase in finished product would more than take care of the cost of hydration, so that this material can be put on the market at a price lower than the quicklime. The hydrate can be more thoroughly mixed with sand, water, and other ingredients, so that it is about equal in efficiency to common lime. The fact that it is so much easier and certain than quicklime more than offsets any slight disadvantage it may have on account of water which it takes up in hydration.—**S. Y. Brigham,** *Eng. News, Vol. L., No. 9*, pp. 177–179.

Diffusion and Compression of Metal Filings.

THE author thinks the formation of an alloy and the combination of two polished plates from alloyable metals on the contact place, as obtained by Spring, to be due to diffusion. Similar diffusion phenomena are likely to play a greater part in connection with solid bodies than hitherto supposed, the formation of so-called contact minerals as well as the gradual hardening of masonry, being possibly due to them. Out of a number of specimens, obtained from metal filings by the application of pressures up to 50,000 kg., the results were rather different according to the material used. On compressing copper, iron, steel, or red metal filings, pieces of quite superficial connection were obtained, being liable to be readily destroyed. In the case of more ductile metals or metal alloys, such as lead, or white bearing metal, being exposed to high pressures, quite different phenomena were obtained. The author succeeded in obtaining from filings exposed to a pressure of 50,000 kg., a perfectly homogeneous pressure piece, being denser than castings. From these experiments and facts it is inferred that with increasing pressures the connection, being adhesion, is more and more increased, until it passes into cohesion, the latter thus being nothing else than increased adhesion. The author thinks compressed white bearing metal to afford many advantages as compared with castings, as it will more closely fill the matrices, apart from its being readily plated with nickel, copper, etc. Further experiments show even iron filings to be readily soldered to one another on being exposed to high temperatures; the same appears to be the case with copper, brought to a

red heat, against the opinion of many experimenters. — **Prof. Hof,** *Zeitschr. Ver. Deutsch. Ingen., Vol. XLVII., No. 37,* pp. 1349-50, *Sept. 12, 1903.—A.G.*

Iron Portland Cement.

Tests made in the Austrian Imperial Laboratories on the iron Portland cement produced by the Stein process have given most satisfactory results, the following figures being relative to iron Portland cement mixed with three parts of sand:

	Tensile strength.		Press. strength.	
	kg.	cm².	kg.	cm².
After 4 days' hardening... ..	26	88	270	00
After 28 days' hardening.....	38	25	375	75

These results show that the cement in question surpasses any Portland cement made from natural raw materials. Further tests give evidence of the specially high degree of residual hardening, being one of the special advantages of iron Portland cement as compared with ordinary Portland cement. Iron Portland cement is made not only from the slag of grey pig-iron, the slag remaining from the production of refined iron being, in most cases, also available. Experience has shown that, using a convenient process, it is possible to produce from the slag of refined iron, not only a high-grade cement, but to ensure at the same time a considerable saving of fuel. The presence of metal-oxide, according to Le Chatellier's experiments, will, moreover, augment the resistance of Portland cement against the noxious influences of the sulphates contained in sea-water; iron Portland cement made from refined iron slag being thus preferable to ordinary Portland cement for constructions in sea-water. The Krupp firm have even obtained a patent for a process, enabling Portland cement to be improved in this respect by additions of metal oxide.—**C. Ritter von Schwarz,** *Stahl und Eisen, Vol. XXIII., No. 18,* pp. 1044-1045.—*A. G.*

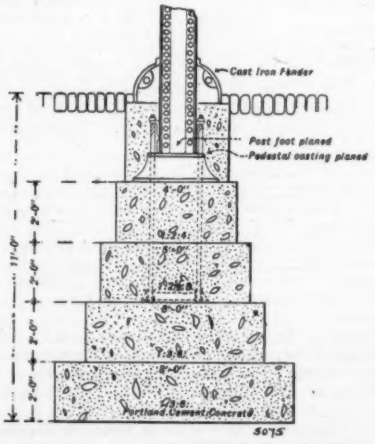
Porous Brass Castings.

THE cause of leaky castings lies in the metal, and every effort should be made to obtain it as free from oxide as possible. To accomplish this, it is recommended to use only ingot copper, and to melt it in the presence of and under charcoal, or other carbonaceous matter, and never allow it to become overheated; also to use some deoxidiser, as, for instance, phosphor tin, in the proportion of ½-lb. per cwt. of metal, and to be very watchful of new heats, the safest plan being to melt the metal twice. When purified metal is used, devices for preventing the dross entering the casting will scarcely be necessary. Dross and other impurities are lighter than the metal, and the idea of the "skim gate" is to dam the metal into a column, into which the dross rises, like a cork in water, and where it will stay, provided the column is held up by proper pouring, the sound metal from the bottom passing by a suitable channel to the mould. A "whirl gate" consists of a riser and pouring sprue, the channel connecting the two being cut at a tangent to the circumference of the riser, the contents of which are thus given a rotary motion which holds the dross in the centre of the vortex; a channel or runner connects riser and mould. Another idea is to use a riser and sprue, which latter is connected to the riser by a small gate, which permits of the sprue being kept full of metal while pouring, the dross being held back and the riser merely feeding the casting and preventing shrinkage. In conjunction with these various gates, a horn sprue is used in some foundries to carry the metal from riser to mould.—**C. Vickers,** *Amer. Machst., Vol. XXVI., No, 32,* pp. 1107-1108.

CONSTRUCTIONAL.

Foundations for the Elevated Structure of the Boston Elevated Railway.

IN general the foundations for the elevated structure of the Boston Elevated Railway commence 10 ft. or 12 ft. below the surface of the ground. They are built of Portland cement concrete laid in courses about 2 ft. thick, as in Fig. 1, the upper course being 4½ ft. square, on which is set a cast-iron pedestal 12 ins. high to receive the steel post. Four anchor bolts are built into the upper courses of the concrete, the lower ends being secured to an anchor casting and the upper ends passing through the pedestal and lugs on the steel posts. Provision is made for the dead-load of structure and track and a live load of 50-ton cars, each 40 ft. long, this live load being heavier than the present rolling stock so as to provide for future developments. Provision is also made for a horizontal force, applied at the rail transversely to the structure, of 450 lbs. per linear foot of span; and the foundations are designed to carry an additional track to the two

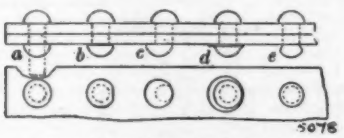


FOUNDATION FOR BOSTON ELEVATED RAILWAY.

now in use. The foundations were designed to meet the following conditions: (1) Under maximum vertical and horizontal loads to give a pressure on the earth or piles not in excess of their assumed safe bearing power; (2) under minimum vertical and maximum horizontal loads capable of acting with it, or, under the condition of least stability against overturning, to have a factor of 3 against overturning at the edge; (3) under each of the above conditions the stresses in the concrete for foundations and anchor bolts not to exceed safe limits. For the determination of safe pressure to use on concrete a large number of Portland cement concrete 12-in. cubes were prepared and tested by the United States Government at Watertown Arsenal.* The stresses allowed in the concrete were as follows: Compressive, from 300 lbs. to 450 lbs. per sq. in., tensile not above 30 lbs. per sq. in.; maximum tension in anchor bolts, 16,000 lbs. per sq. in. Where the best soil was encountered from 2·3 tons to 3 tons were allowed per sq. ft., and where the foundations rest on clay a mean pressure of 2 tons per sq. ft. was allowed. The mean pressure allowed on piles was 10 tons per pile. The concrete was composed of Portland cement, broken stone and sand, the usual proportions being 1 : 2½ : 5. The difficulties in building the foundations were due to soft bottom and the large number of underground structures encountered. The number of foundations built in the streets was 1,133, and of these about one-half cost 260 dols. each in round figures, or 9·50 dols. per linear foot of double-track structure. The remainder averaged about 700 dols. each, or 25·50 dols. per linear foot of double-track structure. Several drawings are given illustrating special design necessary for avoiding underground structures.—**G. A. Kimball,** *Pres. Boston Soc. C.E., Jnl. Assoc. Eng. Soc., Vol. XXX., No. 6,* pp. 351–355.

Rivets in Structural Steel Work.

In the diagram are shown some of the more frequent imperfections in rivet work, resulting from carelessness. At *a* is a perfectly driven rivet. At *b* is a loose rivet which has been "caulked," to make it appear right under the inspector's hammer. Careless manipulation may result in the condition shown at *c*, where the head is not concentric with the shank. The condition

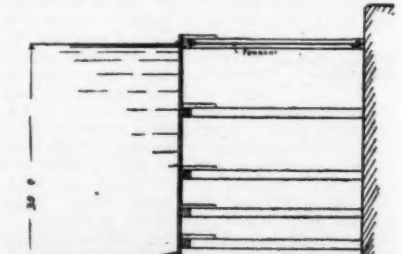


RIVETS IN STRUCTURAL STEEL WORK.

shown at *d* results from too much metal in the shank of the rivet before driving, giving a "soldier-cap" head. The reverse of this is shown at *e*. These are only a few of the errors of this kind that may be observed in any shop. Combinations of two or more of the forms shown occur not infrequently, and an almost endless variety of changes may be rung on each one. Of the four types, *b* and *e* should be condemned whenever found, being not only bad workmanship, but unreliable. *c* and *d* probably develop the full strength of the rivet, and may be allowed to pass if strength is the only consideration; but if the work is to be exposed, they should be cut out and replaced, as they are sure to look ragged in finished work. The nearest approach to a theoretically perfect rivet is probably the turned bolt, which is occasionally used for field connections. In such cases it is the practice of some engineers to require the holes to be drilled instead of punched, or "sub-punched and reamed." The bolt is turned to a driving fit, and the threaded part is of slightly reduced diameter, the shoulder protecting the thread while the bolt is driven home. To keep the nut in place after it is screwed up tight, the projecting threaded end of the bolt is upset against the nut—**C. J. Tilden,** *Harvard Eng. Jnl., Rept. Mech. Wld., Vol. XXXIV., No. 872,* pp. 141–2.

Temporary Dams.

Among the numerous types of temporary dams may be mentioned cassions, earthen dams, masonry or concrete dams, coffer dams, and dams formed by sheet piling, each of which has its own particular claim as being most suited to different descriptions of work. The author confines himself to the one type known as the "flitch" dam, with which he has considerable experience. Like most things, the flitch dam has its advantages and disadvantages: it cannot be used when there is no abutment for the shores within a suitable distance, or when the foundations are of a soft and yielding nature. The flitch dam consists of vertical timbers connected to walings spaced to suit the water pressure and supported vertically by means of shores, with a toe of clay on the outside (see Fig.). Perfection, to a certain extent, follows from experience, and the methods the author describes have mostly been arrived at by experience with this type of dam. The subject is dealt with stage by stage, in the order in which



FLITCH DAM.

* "Report of the Tests of Metals, etc., at the Watertown Arsenal, 1899," pp. 719–781.

the work would be carried out, and for this purpose the paper is divided into two parts, giving detailed particulars relative to the design and construction of flitch dams.—**G. C. Kenyon,** *Trans. Liverpool Eng. Soc., Vol. XXIV.*, pp. 113–141.

METALLURGY.

A Novel Method for ascertaining the Molecular state of Iron and Steel.

THE author describes a novel method for ascertaining the physical state of axles and other iron and steel parts, this method being based on the magnetic properties of iron and its modifications. It may be inferred from the principles of magnetism that, if an iron or steel part of a machine is examined before it is put to work, recording graphically the values of the magnetic induction for variable magnetising forces, a representation of the magnetic properties of this part will be obtained. Now the axles of railway carriages and locomotives, as well as many other parts of machines, are exposed to peculiar variations in their physical state, due to the vibrations and shocks they undergo during operation. These vibrations will result in a crystallised state being eventually produced, rendering the material in question both weak and brittle. These factors at the same time diminish the *residual* magnetic phenomena, causing the part tested to assume more rapidly the average state corresponding to the magnetic force acting on it; in other words, the rising and descending branches of the magnetic curve will become little different from one another. There must therefore exist characteristic differences between the magnetisation curves of an axle or other iron part as taken at different times of its service, these differences being determinable by experiment, observing various specimens and recording the corresponding curves, when a subsequent magnetic test of the specimen will allow of conclusions being drawn as to its actual safety.—**A. Sandarán,** *Energ. Eléctria, Madrid, Vol. V.*, pp. 14–16 and 23–27, *1903.*—*A. G.*

Magnetite Deposits.

AFTER describing the geological features of the magnetite ore deposits of Mineville, New York, the author passes on to a description of the method of magnetic concentration employed to free the ores from phosphorus. Some two years ago a new type of concentration plant was installed with promising success. The successful outcome of this experiment was due to the Wetherill method of magnetic separation. The success of this process lies in its ability to attract materials of slightly magnetic qualities by using a highly condensed magnetic field. The machines used are of two types, both of which can be used in the treatment of iron ores. In the first type the particles of magnetic attractability are lifted away from the stream of mixed materials, brought under the magnets, and then carried away from the non-magnetic particles. In the second type the moving ore is affected magnetically in such a way as to deflect the different ingredients in different directions. Before treating, the ore is crushed to sufficient fineness to free unlike mineral grains, and it should also be dry in order that there may be no adherence of mineral particles due to moisture. With the first type of separator, known as the Rowand, the ore is fed by a feed roller on to a travelling belt, which carries it under the magnets; the number of these depending on the number of products to be separated. For treating the Mineville ore there are two. As the ore passes under the first magnet the magnetic grains are lifted upwards, and coming against the lower surface of another belt, moving at right angles to the first one, are held against it long enough to be carried to one side and dropped into a hopper. The mixture left on the feed belt comes under the second magnet, which is of much greater strength, and here the hornblende is removed and carried to one side. The remainder, consisting of apatite and a little quartz, passes off at the end of the belt and furnishes a product high in phosphoric acid, and probably suitable for fertiliser manufacture. By this method the phosphorus contents of the ore have been reduced from 1·6 per cent. down to 0·5 or 0·8 per cent. With this type of machine, if the material is fed too rapidly on the belt, there may be danger of its heaping up, so that when particles of the ore are rapidly drawn up toward the magnets, particles of non-magnetic material may be held in between them, and thus impurities get into the concentrate. In the second type of machine this difficulty is overcome to a certain extent, in that the ore falls vertically in a thin sheet in front of the magnet. As it passes before the pole piece the magnetic particles are deflected sufficiently to be thrown on to a screen from which they fall into a hopper for the concentrate.—**Heinrich Reis,** *Mines and Minerals, Vol. XXIV., No. 2*, pp. 49–51.—*P. L.*

Standard Test-Bars for Cast-Iron.

IN a paper presented to the American Society for testing materials, the author urges the necessity of adopting test-pieces of standard size, suitable for the different grades of cast-iron. This necessity is emphasised by the fact, that from one ladle of iron it is possible to obtain castings having widely different physical properties by simply regulating the rate of cooling after pouring in the moulds. A good illustration of this may be shown by casting in grey iron a wedged-shaped bar of the following size—6 ft. long, 6 ins. square at the thick end, and tapering down to ¼ in. square at the thin end. This bar broken into short pieces will show almost every grade of cast-iron, commencing with white at the thin end of the wedge, gradually merging into grey as the thicker portions are approached, and finally showing a typical full-grey at the thick end of the wedge. It must also be remembered that as the grade of iron varies, so will the mechanical properties as shown by the tensile and transverse tests. A further instance of variation may be shown by casting a solid block of iron 15 ins. by 15 ins. by 15 ins., and afterwards cutting it up into bars for tensile and transverse tests. A block so made was cut up into 64 pieces, 1 in. by 1 in. by 14 ins., which were broken in a transverse testing machine on supports 12 ins. apart. The highest records of

strength were found in the outside rows and the lowest in the bars cut from the centre. For example, the average breaking-stress of the bars forming the bottom row was 2,800 lbs., whilst the average of the centre of the block was only 1,750 lbs. If several test-bars are cast from one ladle all of the same length but varying in diameter, the tensile results will also vary considerably, as a rule the larger bars showing much less strength per square inch than the smaller bars. A glance at the following table, which gives the diameters as cast, the finished diameter of the test-pieces and the ultimate strength, will support this statement:—

Diameter as Cast.	Finished Diameter.	Area.	Ultimate Strength, lbs. per sq. inch.
1⅝"	1·129"	1·000"	29,300
1⅝"	1·129"	1·000"	28,900
1½"	0·899"	0·635"	33,160
1¼"	0·899"	0·635"	33,200

Many similar test have been made, all confirming the foregoing statements. These results conclusively show the importance of adopting standard sizes of test-bars for determining the strength of cast-iron when poured into casting of different dimensions.—**A. E. Outerbridge, jun.**, *Amer. Mnfr. & Iron World, Vol. LXXIII., No. 10*, pp. 378–379.—*P.L.*

The Volumetric Estimation of Manganese in Iron and Steel.

A SERIES of manganese determinations in various steels and irons were conducted as follows: 0·2 gram of the samples, and a standard steel of known manganese contents were weighed into suitable test tubes, and 10 cc. of 1·20 nitric acid added to each. The solutions were heated until the samples were dissolved, and all nitrous fumes driven off; 15 cc. of a solution of silver nitrate equal to 0·02 gram Ag., No. 3 (1·33 gram of the salt per litre of water), were added to each. After adding about 0·5 gram ammonium persulphate salt the solutions were heated until oxidation commenced, and then for half a minute longer. In preparing the iron samples 1 gram was dissolved in 30 cc. 1·20 nitric acid, filtered into a 100 cc. flask, and diluted to the mark. After thoroughly mixing, 20 cc. of the solution were transferred to beakers, and a little ammonium persulphate added to destroy the combined carbon. Five cc. of a solution of silver nitrate (4 grams of the salt per litre of water), and a little more persulphate were added, and the procedure continued the same as for steels. When the permanganic acid solutions were cold they were treated as follows. First series: Manganese estimated color-metrically. Second series: The silver was precipitated as chloride, and the solutions were then titrated with a sodium arsenite solution until the pink colour was destroyed. Third series: The solutions were titrated with sodium arsenite without precipitating the silver as chloride. Fourth series: The solutions were titrated with hydrogen peroxide without precipitating the silver as chloride. The following are the results obtained:

	1st Series.	2nd Series.	3rd Series.	4th Series.
	%	%	%	%
Steel No. 18	0·28	0·27	0·28	0·27
,, 17	0·47	0·46	0·48	0·47
,, 11	0·53	0·55	0·54	0·53
,, 22	0·57	0·59	0·59	0·59
,, 26	0·40	0·44	0·43	0·43
,, 33	0·49	0·49	0·49	0·49
,, 90	0·90	0·92	0·90	0·89
,, 47	0·43	—	0·43	0·43
Iron S.	0·19	—	0·21	0·19
,, 712	0·22	—	0·22	0·21
,, 713	0·23	—	0·23	0·24
,, 716	0·24	—	0·24	0·24
,, 828	0·16	—	0·16	0·15
,, 813	0·13	—	0·11	0·11
,, 829	0·18	—	0·17	0·19
Steel No. 68	0·73	0·72	0·74	0·74

It will be noted that the results all agree closely, whether the silver was separated or not, and that hydrogen peroxide may be used as well as sodium arsenite. The end point in all these titrations is not as sharp as might be desired, but it appears to be sharper if the silver is not precipitated. If the silver is not precipitated, the titration must be done quickly as the persulphate and silver nitrate in solution react to reproduce the colour if allowed to stand.—**H. E. Walters**, *Proc. Eng. Soc., West Pennsylvania, Vol. XIX., No. 7*, pp. 43–45.—*P.L.*

The Metallography of Iron and Steel.

THE chief substances present in ordinary commercial iron and steel are—(1) Pure, or nearly pure, iron, called "ferrite." (2) A definite carbide of iron, Fe_3C, called "cementite." Ferrite is soft, weak, and very ductile. It has a high electric conductivity, and its properties in general resemble those of copper, with the one exception of colour. Cementite is harder than glass and nearly as brittle, but probably strong under gradually and axially applied stress. The steels which are especially soft and ductile, such as rivet and boiler-plate steels, consist chiefly of ferrite. The harder steels, as, for instance, the rail steels, have a much larger proportion of cementite. As the amount of cementite in steels increases the amount of ferrite decreases, and the hardness increases continuously. The tensile strength, however, reaches a maximum when the cementite amounts to about 15 per cent. of the whole; with further increase of cementite the tenacity decreases. Besides these two constituents of prime importance, ferrite and cementite, there are three others of moment; these are graphite, slag, and austenite. Graphite, an important constituent of grey cast-iron, represents pure, or nearly pure, carbon in thin flexible

sheets, which form a more or less continuous skeleton running through the mass. Slag is met with in wrought iron, but not in steel. Steel hardened by sudden cooling from a red heat consists essentially of austenite, a solid solution of carbon in iron of varying degrees of concentration. When austenite contains as much as 1 per cent. carbon it is intensely hard and brittle; indeed, its hardness and brittleness are roughly proportionate to the amount of carbon it contains. Hence steels for purposes which require extreme hardness, such as files and other tools for cutting metals and wood, have from about 0·75 to 2 per cent. carbon, enough to give them the degree of hardness required, but not enough to cause a prohibitory degree of brittleness, and they are hardened by sudden cooling. Slowly cooled steels consist essentially of pearlite plus ferrite if the carbon is below 0·9 per cent., or pearlite plus cementite if the carbon is above 0·9 per cent. Pearlite consists of interstratified plates of ferrite and cementite, in the ratio of about six parts by weight of the former to one of the latter. Amongst others of the so-called constituents of steel, martensite, troostite, and sorbite are described as transition forms between austenite, on the one hand, and ferrite and cementite on the other, probably containing all three of these substances, but in varying proportions—**Prof. H. M. Howe,** *Eng. Mag., Vol. XXV., No. 6,* pp. 801-812 —*P. L.*

Melting Ratio in Brass Foundries.

THE writer gives a series of results obtained by melting an alloy of 90 per cent. copper and 10 per cent tin under different conditions. The various methods of melting, the fuel employed, percentage loss of the alloys and melting ratios are tabulated as follows:—

No.	Metal melted in lbs.	Method.	Fuel.	Weight of fuel used in lbs.	Loss in Melting per cent.	Melting ratio per lb. of fuel.
1	400	Crucible natural draught ...	Charcoal	318	0·89	1·25
2	400	,, ,, ,, ...	Purified Coke	300	1·22	1·33
3	400	,, forced draught ...	,,	348	2·18	1·12
4	400	,, ,, ,, ...	Coal	325	1·04	1·20
5	17,305	Cupola	Purified Coke	2,184	7·93	7·91
6	2,240	Reverberatory	Coal	1,768	3·57	1·26

The fuel weights given include kindling the furnaces and melting the alloys for the production of castings. From his experiments, the writer concludes that bronze melted in natural draught crucible furnaces with purified gas-coke will produce better castings than that melted by any other means. —**J. F. Buchanan,** *The Foundry, Sept., 1903,* pp. 20-23.—*P. L.*

Crystallisation of Iron and Steel.

AT a recent meeting of the Pacific Coast Railway Club a topical discussion on the crystallisation of iron and steel was proposed, and Mr. W. A. Doble, in response to numerous questions, gave an account of his studies in this direction. The speaker's preliminary remarks may be summarised under the following heads: (1) All metals are primarily crystalline—that is they are built up of a number of small crystals; (2) the term "crystallised fracture," or failure of a part due to crystallisation in the metal, simply denotes that the crystals are of abnormal size; (3) this abnormal crystallisation is caused by the heat treatment of the metal—in other words, it has been formed before the metal enters into service, and has not been caused by the character of the service. It is generally inferred that abnormal crystallisation is developed during working life—that is, the original fine structure is changed by service conditions, such as vibration, shock, and so forth, into a coarse structure. Were this the case then the *C*-string of a piano, which is subjected to many thousand vibrations per minute, would have excellent opportunities for developing this abnormal type of crystallisation. Yet, as a matter of fact, piano strings do not develop this coarse structure. If a bar of steel be heated up to a high temperature and slowly cooled, its fracture will be coarsely crystalline. If, however, mechanical work is put on the bar in its hot condition, then in its cold state it will give a fine and tough fracture. Many forgings have to be reheated a number of times, which results in the character of the structure throughout the forging varying between the extreme limits of fine and coarse, with a consequent variation in the mechanical properties of different sections. This inequality may be overcome by the adoption of one of two methods. First, on completion of the forging process, by again reheating to a uniform temperature and slowly cooling. This treatment gives a uniform structure throughout the forging, and also relieves internal strains; but the method will not necessarily give the highest mechanical properties, because the structure is in its softest and most open condition. Better results are obtained by heating to a uniform "hardening heat" and quenching in oil. By this treatment the structure of the steel is converted into a fine granular one; but, at the same time, the forging is more or less internally strained. After quenching the forgings are reheated to a dark red heat and then slowly cooled, this treatment relieving internal strains and removing brittleness, but not affecting the fine character of the fracture. Test pieces cut from a 3½ per cent. nickel-steel shaft treated in this manner yielded the following results:

Elastic Limit. Lbs. per sq. in.	Ultimate Strength. Lbs. per sq. in.	Elongation on 2″ %
62,130 ...	95,740 ...	21·5

—**W. A. Doble,** *Railway Age, Vol. XXXVI, No. 10,* pp. 293-296.—*P. L.*

The Metal Testing Laboratory of the National Conservatoire of Arts and Crafts of Paris.

THE object of the laboratory is a twofold one, viz. to repeat the experimented work of others, and to carry on original research. Alloys and metals are at present melted in a furnace of the Bigot system, containing a crucible of 2 litres capacity, and capable of realising a temperature of from 1,400 to 1,600 degs. Cent. The acquisition of a coke crucible furnace is contemplated, which will be capable of yielding ingots of about 25 kgs. The adoption of the Goldschmidt method for the reduction of ores is also contemplated. For the industrial heat treatment of metals the laboratory is equipped with several reheating furnaces, the temperatures of which are controlled by means of a suitable pyrometric installation. Of the reheating furnaces, three are electrically heated, and may be utilised either for melting or for heat treatment. In the first one, M. Gabreau has sought to realise a furnace at once economical and which, at the same time, permits of the regular heating of crucibles or of pieces of metal. When used for melting, the crucible is placed between two arcs, and supported by a long refractory piece which passes through the bottom of the furnace. If the crucible were a fixture between the two arcs, it would in the course of a few minutes be burnt, or even melted, in the locality of the most intense heat. To overcome this M. Gabreau has applied to the crucible a movement of rotation, and at the same time a falling and rising movement, by which means the crucible is uniformly heated. The first movement is obtained by means of a strap passing round the projecting portion of the vertical tree which supports the crucible, and causing it to turn. The second movement is provoked by an electro-magnet, which attracts or repulses the tree according to its circuit. This arrangement assures successful melting, and by means of it metals such as soft steel and nickel may be liquefied in a few minutes. As an instance may be quoted the complete liquefaction of 300 gms. of nickel in 16 mins., commencing with a cold furnace; the maximum intensity being 75 amps. This apparatus, whilst heating well, possesses the inconvenience of heating too quickly, and in order to obtain perfect control and regularity in the heating the two following furnaces of the Heræus system have been installed. They consist essentially of a porcelain tube surrounded by a platinum spiral, through which the heating current passes. One is horizontal and the other vertical, the internal diameter of the first is 60 mm. and it has a length of 60 cm., the height of the second tube being 150 mm. In the horizontal furnace a current of 50 amps. under 110 volts will give a maximum temperature of 1,400 degs. C. In the vertical furnace 15 amps. under 110 volts gives a maximum of 1,200 degs. C. By means of a rheostat, a constant temperature varying from 200 degs. C. up to the maximum of either furnace may be maintained. It is intended to use the horizontal furnace for determining the critical points of steel, the points of magnetic transformation and so forth, and it may be further utilised for mechanical tests of metals at high temperatures. The vertical furnace is fitted to receive a small crucible, and will he employed for determining the melting points of metals and alloys. The characteristic feature of these furnaces lies in the small quantity of platinum used. The platinum surrounding the tubes is in the form of thin ribbon, which gives a greater heating surface with far less weight than if the platinum were in the form of wire. The ribbon employed has a width of 13 millimetres and a thickness of $\frac{7}{1000}$ of a millimetre. Consequently only 20 grammes were required for the horizontal furnace and 5 grammes only for the vertical furnace. The micrographic laboratory is to be fitted with an adaptation of Le Chatelier's microscope, and by means of suitable objectives magnifications up to 1,500 diameters are anticipated. The chemical laboratory is equipped with all the necessary facilities for metallurgical analysis. —**P. Breuil** (Chief of the Metallurgical Section), *Le Génie Civil, Vol. XLIII., No. 21*, pp. 324–327. —*P. L.*

Alloys of Iron and Tungsten.

FOR many years the addition of tungsten used in the production of "self-hardening" steel has been by the oxide, or by means of a metallic powder, though owing to more recent improvements in the manufactures of the ferro alloy and of the metal itself this form is coming into general use. Ferro-tungsten, in addition to iron, contains from 1 to 4 per cent. carbon, and from 30 to 80 per cent. tungsten. Whilst for the production of tool steel, the carbon of the ferro-tungsten is by no means detrimental, in the present research in which it was desired to keep down all elements other than iron and tungsten, an alloy low in carbon was desired. The author therefore obtained a special ferro-tungsten of the following analysis:

C.	Si.	S.	P.	Mn.	Cr.	Fe.	W.	Total
2·87	0·75	0·05	0·02	1·03	0·16	13·4	79·5	=98·05

the remaining 2 per cent. being due to oxides of tungsten. Although a satisfactory ferro-tungsten was obtained, the carbon inevitably present was such that in the resultant alloys its amount necessarily increased with the tungsten percentage. However, the carbon present in the first six alloys will not materially affect their mechanical properties, but as regards the remainder, its effect may be more or less considerable. With the exception of the carbon the results are not affected by other elements, the manganese varying slightly from the low percentage of 0·18 to 0 29 per cent., and the full set of specimens here presented is, as far as the author knows, the only one yet produced with such a wide range of variation in the tungsten, and in which the other elements, with the exception of carbon in specimens "I" to "M," are present in low percentages only. The analyses of the thirteen alloys are as set out on page 460. Bars of the various alloys were cast 2½ ins. by 2½ ins. by 30 ins., and in each case a set of smaller bars for bending-tests were made. In the molten condition the alloys were slightly less fluid than ordinary steel, but no trouble was experienced in

TESTS OF ALLOYS OF IRON AND TUNGSTEN.

Mark.	W. %	Unannealed Test Bars.				Annealed Test Bars.				Forged Compression Tests.		Cast Bending Strips.		Forged Bending Strips.		Welding Tests.	Corrosion Tests on Forged Material.
		Elastic Limit. Tons per sq. in.	Breaking Load. Tons per sq. in.	Elongation. %	Reduction of Area %	Elastic Limit. Tons per sq. in.	Breaking Load. Tons per sq. in.	Elongation. %	Reduction of Area %	Elastic Limit. Tons.	Shortening % by 100 tons.	Unannealed.	Annealed.	Unannealed.	Annealed.		
A	0·10	20	25	35	60	14	22	43	65	—	—	Bent to 56°	Bent to 105°	Bent to Double	Bent to Double	—	Loss % —
B	0·20	22	27	40	60	16	22	46	66	30	52	64°	Double	,,	,,	would not weld	5
C	0·40	24	31	33	59	18	25	39	60	30	50	31°	158°	,,	,,	—	—
D	0·35	20	27	37	58	16	23	45	69	—	—	51°	Double	,,	,,	would not weld	—
E	0·81	29	32	35	63	18	26	37	53	—	—	31°	,,	,,	,,	,,	—
F	1·20	25	32	25	49	17	27	37	54	—	—	53°	,,	,,	,,	,,	—
G	1·49	20	34	26	46	19	28	37	54	30	48	18°	,,	,,	,,	,,	3
H	3·40	31	41	29	51	23	34	34	53	40	39	23°	,,	110°	,,	—	2
I	7·47	37	63	14	18	24	40	25	38	40	22	6°	41°	84°	,,	—	4
J	8·33	45	64	2	2	25	42	23	32	—	—	6°	32°	45°	,,	—	—
K	10·56	55	80	5	4	28	48	10	10	—	—	6°	28°	10°	,,	—	—
L	15·65	Too hard to machine.				27	57	3	2	50	9	3°	10°	5°	168°	—	6
M	16·18	50	Broke short at 55	½	¼	27	43	1	3/32	70	2	2°	6°	3°	95°	—	5

making the various test-bars. The malleability when hot, whilst fairly good, was not equal to ordinary commercial steel and some difficulty was experienced in forging the bars. No doubt if the manganese had been slightly increased there would have been no special difficulty in forging, but it was of course desirable to keep all foreign elements down to the lowest point. Results

ANALYSES OF ALLOYS.

Mark.	C. %	Si. %	S. %	P. %	Mn. %	W. %	Intended percentage of W.
A	0·13	0·03	0·12	0·06	0·22	0·10	0·125
B	0·15	0·04	—	—	0·22	0·20	0·250
C	0·15	0·07	0·10	0·08	0·29	0·40	0·500
D	0·13	0·04	—	—	0·18	0·35	0·750
E	0·21	0·05	—	—	0·18	0·81	1·000
F	0·22	0·05	—	—	0·18	1·20	1·500
G	0·21	0·07	0·12	0·07	0·25	1·49	2·000
H	0·28	0·06	0·10	0·06	0·28	3·40	4·000
I	0·38	0·11	—	—	0·20	7·47	6·000
J	0·46	0·08	—	0·06	0·28	8·33	9·00
K	0·63	0·10	—	—	0·25	10·56	12·00
L	0·76	0·19	—	—	0·28	15·65	15·00
M	0·78	0·15	0·15	0·04	0·27	16·18	20·00

obtained from the various tests of these alloys are given in the table on preceding page. It will be seen that an increase in tungsten is accompanied by an increase in hardness and a decrease in toughness. Welding tests were made, and as none of the alloys containing from 0·20 per cent. to 1·49 per cent. were found to show any welding tendency, the higher ones were not tested. The presence of tungsten in an iron alloy appears to act in the same manner as Mn, Cr, Si, Al and Ni, that is, it greatly hinders or prohibits the welding together of two specimens. Corrosion tests were made on forged strips $1\frac{1}{2}$ in. × $\frac{5}{16}$ in. × $3\frac{1}{2}$ ins. These strips were weighed and immersed for 21 days in sulphuric acid of 50 per cent. strength, reweighed, and the loss noted. This loss did not greatly differ from the results obtained on the tests of Mn, Si, Al and Cr alloys. *Magnetic Qualities:* The addition of tungsten to ordinary high carbon steel increases the retentiveness, and such steel is suitable for permanent magnets. Tugsten *per se* does not confer any special property, as the alloys produced in this research did not possess special retentiveness. This is owing to their lowness in carbon, hence it is clear that the action of tungsten is only indirect, that is, it causes the carbon present to become very intimately combined. Tungsten in the presence of low carbon interferes with the permeability much less than Cr, Ni, and other elements. Probably, therefore, tungsten steel with high carbon more readily permits the steel to become permanently magnetised, the intimate union of the carbon and iron in the quenched steel enabling the imparted magnetic energy to be retained.—**R. A. Hadfield, M.Inst.C.E.,** *Proc. Iron and Steel Inst., Sept., 1903,* pp. 1-68. —*P.L.*

Drop Forging.

DROP forging differs from hand forging, in that the shape to be formed is not obtained by slowly fashioning it with hammer, sledge, sets, fullers, flatters, and other special tools, but is secured by compressing the metal in a few blows between two dies, which have been previously wrought to the desired shape. Necessarily the process is limited to such shapes as can be made in dies under pressure from one direction. The high initial cost of the dies when borne by a small number of forgings is prohibitive, but when the number of duplicate forgings is large, and the preliminary expense can be divided among thousands, the reliability of the product is such that drop forgings are preferred to hand forgings or to castings. Compared with hand forgings, drop forgings are preferred because of their accuracy of shape, perfect uniformity, and low cost. Only a very slight finishing allowance is necessary, and parts that do not require machining need only to be polished. Compared with steel castings, drop forgings present an entire freedom from blowholes, and therefore greater reliability. Many small pieces, in quantity, can be made more economically than steel castings, and larger pieces, when not too complicated, and if wanted in sufficient numbers, can also compete in cost. Drop forgings, owing to their greater strength and perfect uniformity, are superior to castings of malleable cast-iron, the costs averaging about the same when the former are made in quantity. In general, any metal permitting of forging is applicable to drop forging, but as a rule low-carbon steel is preferred to steel of higher carbon, because it may be heated to higher temperatures for forging, thus resulting in longer life for the dies.—**D. Goddard,** *Proc. Engineers Soc. Western Pennsylvania, Vol. XIX., No. 5,* pp. 292-298.—*P. L.*

On January 1st, 1904, the title of this Publication will be altered to THE ENGINEERING REVIEW.

PRIME MOVERS.

A Comparison between Axial and Modern Radial Turbines.

After pointing out the fact that the progress obtained in the utilisation of hydraulic power is mainly due to the improvements of turbines, the author states that axial turbines are much less satisfactory than modern radial turbines, one of the main points being the imperfect effect of the suction pipe in highly located turbines. The losses involved are of two kinds, as, on account of the sudden change in the speed, losses by shock and vortex movements will occur in addition to the air stagnating below the running wheel in the suction pipe, because of the air originally present in the latter. In order, therefore, to maintain the issue losses at the issue within suitable limits (2 to 6 per cent.), axial turbines have to be placed immediately above the lower water level, or even to be immersed into the lower water, this resulting in a very inconvenient position of the engine. A further drawback to the use of axial turbines is the fact that a great part of the gradient will weigh on the running wheel as hydraulic pressure, thus putting the shaft to high strains. The vertical path of the water, as further pointed out, is on the other hand no material advantage in axial turbines, which are unsuitable also on account of their difficult regulation. These drawbacks are avoided with external radial turbines, while other advantages are obtained. As compared with the difficult regulation of axial turbines, the simple slot pressure regulation, as suggested by Prof. Fink, is much more advantageous. With this regulation the entering angle of the water, with respect to the periphery, is modified by all the guiding vanes being simultaneously rotated by a certain angle, this rotation being possible on account of the cylindrical curvature of the guiding vanes. On a practical instance it is shown that the efficiency of good turbines in the case of water quantities ranging between 70 and 100 per cent. is upwards of 0·8, the maximum amount of ·82 being reached for 80 per cent. The ancient types of Francis turbines gave numbers of revolutions smaller than the modern types, with which both diameters are frequently nearly the same. Though a further increase in the speed by further diminishing the diameter of the running wheel is frequently being made specially by American designers, the author does not think it necessary to construct in any case and anywhere high-speed turbines. Connection in parallel on the same shaft is easier with the radial turbines than is the case of axial turbines on account of the greater modifications the suction pipe is susceptible of. Spiral turbines for high gradients being coupled to a dynamo are quite analogous to centrifugal pumps driven by an electromotor. An advantage of turbines as compared with other power engines is the fact that even without any regulation they will attain at most 1·8 times the normal speed in the case of their running at no load, whereas running without load results in rather serious disturbances in the case of steam engines. Moreover, the fly-masses of turbines may run at much higher speeds than those of steam engines, thus insuring savings in cost.—**Prof. Pfarr,** *Zeitschr. Ver. Deutsch. Ing., No. 39,* pp. 1426–1427, *Sept. 26, 1903.—A. G.*

Heat Engines and the Problem of Liquid Fuel.

It is pointed out that all the different types of heat engines have for five years past been developed to a high degree of perfection; Table 1 records the heat utilisation afforded by each of them according to the latest returns available. From this table it is inferred that the progress made by each of these types is about the same, being about 30 per cent., the Diesel engine thus remaining far ahead of all the similar engines. Explosion motors have made advances as high as 50 per cent. on account of the use of fuels containing water. The second part of the paper treats of alcohol as motive fuel, it being shown that such endeavours as have been made, in order to use alcohol in connection with the generation of power, are devoid of any rational basis. In fact, the cost of operation in the case of spirit being used is about 4½ times greater than with cheap paraffine and raw oils. Some different types of Diesel motors are next discussed by the aid of diagrams, and the problem of liquid fuel is dealt with in the last part of the paper. The Diesel engine, in the words of Professor von Lossow, is for liquid fuel what the steam engine and power-gas motors have been and are for solid fuel, only in a much simpler and more economical way, embodying the general

HEAT ENGINES AND THE PROBLEM OF LIQUID FUEL.—TABLE I.

Kind of Engine.	Consumption of Heat per I.H.P.	Actual Heat Utilisation of Fuel.	Ratio of Actual Heat Utilisation of Raw Fuel.
	Heat Units.	Per Cent.	
3,000 h.p. steam engine, with triple expansion, 12·3 atmospheric boiler pressure, and 314° superheat ...	4,010	15·7	1·0
Power-gas motors	3,200	20·0	1·27
Spirit motors	1,945	32·7	2·08
Diesel thermic power engine...	1,780	35·7	2·24

and, according to our present scientific knowledge, best solution of the problem of utilising liquid fuel for motive-power purposes, and affording new possibilities for industry. The importance of liquid fuel, in the opinion of the author, cannot be over-rated, such fuel being possibly more widespread on the earth than even coal in its different forms.—**R. Diesel,** *Zeitschr. Ver. Deutsch. Ing., Vol. XLVII., No. 38, Sept. 19, 1903,* pp. 1366–75.—*A.G.*

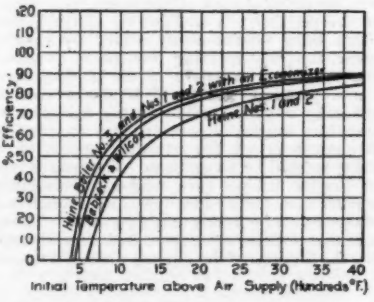
Scotch or Cylindrical Multitubular Boilers.

We already know how to make safe boilers, and that the laws which govern us in the strengths of the various parts are well known, but I wish to obtain opinions as to whether we are not making them too safe and too heavy, and commercially handicapping ourselves. First let us take the boiler shell, and here we find the Board of Trade insist on a factor of safety of 4·5 with first-class construction. Let us assume we want a steel boiler 16-ft. diameter, the plates to have a tensile strength of from 27 to 32 tons per sq. in., and the longitudinal joint to give 85 per cent. of the solid plate, the pressure to be 160 lbs. per sq. in. The thickness of plate would be as follows:—$\frac{P \times 4{\cdot}5 \times D}{\text{Tons} \times 2{,}240 \times 2 \times \%} = t$. Where P = boiler pressure, t = thickness of plate in inches, D = diameter in inches. By this rule the value of $t = 1\frac{1}{2}$ ins. Lloyd's rule for the same boiler would give the following thickness: $\frac{P \times D}{C \times \%} + 2 = t$ in sixteenths, where t = thickness of plate in sixteenths, and C = constant = 21. This gives $t = 1\frac{5}{16}$ ins. It is evident from these figures that either the Board of Trade are asking too much or Lloyd's are passing boilers which have not a sufficient margin of safety, but I contend that both are allowing more than is necessary for safety. Considering all the circumstances, a factor of safety of 3·5 would meet the requirements, and presuming this, taking the same boiler, we have the following:—Board of Trade t = barely $1\frac{1}{16}$ ins. This represents a reduction in shell of about 22 per cent. Next let us take the furnaces. As far as I can gather, a factor of 5 is allowed, and taking the Board of Trade rule we require a plate of the following thickness: $\frac{P \times D}{14{,}000} = t$. Suppose the diameter of the furnace to be 40 ins., the value of $t = \frac{29}{64}$ ins. By Lloyd's rule $\frac{P \times D}{1{,}259} + 2 = t$ in sixteenths, and this gives $t = \frac{7}{16}$. Here we find the authorities in near agreement. But I think we could with perfect safety reduce the thickness from 10 to 15 per cent. In the case of the stays, suppose we take 9,000 lbs. as the standard. The bars must have a tensile strength of 27 tons according to Board of Trade rules, and 26 tons with Lloyd's. If we take the latter we have a factor of safety of nearly $6\frac{1}{2}$. It may be said that the stresses are very unequal on the stays, and there is some truth in this; but surely it does not call for a factor of safety of $6\frac{1}{2}$. Suppose we make a concession to those who hold the latter view, and give a factor of 4·5, we should have a reduction of 30 per cent. Lastly we have the flat plates in a boiler. Here I am at a loss to know what factor of safety has really been allowed by the different authorities, as the formula is largely empirical, but from practical experience I have come to the conclusion that it is quite as high as for any other portion of the boiler.—**E. Nicholl, R.N.R.,** *Trans. Inst. Marine Eng., Vol. XV.,* pp. 3–51.

Some Tests of Boiler and Furnace Efficiencies.

This paper discusses some features of the performances of modern boilers and furnaces. For this purpose two types of boilers, two furnaces, and one stoker were selected. One boiler was 12 tubes high and 16 wide, rated at 400 h.p., and provided with a superheater. This boiler is referred to as boiler *A*. The other boilers were of two sizes. That designated as No. 1 was 15 tubes high and 19 wide; No. 2 was 17 tubes high and 19 wide; No. 3 was identical with No. 2, except that the path of the gases was different. The furnaces under these boilers were identical, and each was fitted with a chain-grate stoker of 72·2 sq. ft. The Table on p. 463 contains the essential data concerning the boiler trials, and Fig. 1 illustrates the relative efficiency of the four boilers considered. The initial temperature is shown through a range that covers all attainable conditions. From an inspection of the curves it appears that the efficiencies of boilers No. 1 and 2 fall upon the same line, and that of *A*, which varied from

FIG. 1.


% Efficiency
Initial Temperature above Air Supply (Hundreds °F.)
Horse Power No. 3 and Nos. 1 and 2 with an Economiser
Horse Nos. 1 and 2
Horse Power No. 3
Babcock & Wilcox

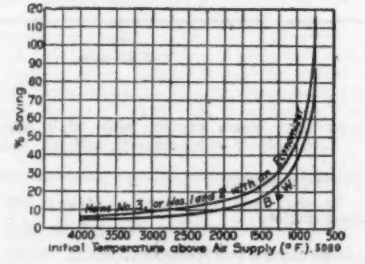


FIG. 2.

	Boilers.			
	Boiler A.	No. 1.	No. 2.	No. 3.
Square feet of water-heating surface	4000·0	4340·0	4800·0	4800·0
Square feet of steam-heating surface	383 0	—	—	—
H.P., standard rating	400·0	434·0	480·0	480·0
,, maker's rating	400·0	570 0	645·0	645·0
,, developed	442·8	431·5	564·3	580·4
,, ,, above standard rating	10·7%	—	17·6%	20·9%
,, ,, below ,, ...	—	·06%	—	—
,, ,, ,, maker's rating	—	32·1 %	14·3%	11·2%
Length of travel of gases in contact with tube-heating surface ft.	21·0	13·0	13·3	36·0
Temperature of escaping gases ... ... °Fahr.	480·2	650·5	657·0	469·0
,, ,, above saturated steam	127·8	273·1	278 0	92·0
,, ,, ,, air supply	407·9	580·2	582·0	394·0
,, saturated steam	352·4	377·4	379·0	377·0
,, superheated steam	455·8	—	—	—
CO_2	9·22	7 93	10·7	10·3

the furnace temperature, is from about 4 per cent. at 4,000 degs. to 20 per cent. at 720 degs. above the efficiency of Nos. 1 and 2; while No. 3 is more efficient than that of *A*. The value of the relative efficiencies from the standpoint of fuel saving is shown in Fig. 2, the efficiency of boilers Nos. 1 and 2 being taken as the standard. The most remarkable feature of this matter of boiler efficiency is that the simple addition of inexpensive baffles, with no labour cost for operation and requiring no additional room in the plant, gives results equal to an economiser requiring a large investment, considerable expense for maintenance, and a large amount of space for its installation.—**A. Bement,** *Proc. Nat. Elec. Light. Assoc., Rept. Mech. Wld., Vol. XXXIV., No. 870,* pp. 110–112.

Entropy.

In the second instalment of his paper on entropy the author discusses the nature of the hypothetical reversible cycle, showing that in such a cycle there is no waste incurred, and therefore no increase of entropy. The entropy of a working substance may increase or diminish during a reversible change, but the entropy of an isolated system and whatever is affected by the change remains constant. In thermodynamics it is inconvenient to discuss the entropy of a whole isolated system, and more useful to consider the entropy of the working substance alone. If the latter increases its entropy by any reversible change, then its increase is "compensated" by an equal decrease of entropy in other things involved in the change. By considering reversible changes and dealing with the entropy of the working substance, without taking the whole isolated system into account, the author leads up to a second and more convenient definition of entropy. The entropy of a body in state *B*, compared with its standard state *A*, is numerically equal to the heat that would have to be taken in to get it from *A* to *B* by reversible changes, divided by the absolute temperature. The author emphasises the fact that, although entropy may be numerically measured in terms of heat that would have to be taken in, and the temperature at which it would come in in changing from *A* to *B* reversibly, the entropy is always greater than

$$\frac{H}{\theta} \text{ or } \int \frac{dH}{\theta}$$

and the incorrect definition in text-books makes the conception of entropy impossible to the reader. The author next enters on a lengthy discussion of the $\theta\phi$ diagram, treating it from the point of view he has set out, and explaining away some confusion of ideas with which its discussion in text-books is usually surrounded. In the next portion of his paper Mr. Swinburne passes from the case of a perfect gas to that of steam. Without reproducing the author's diagrams and much of his text, it would be difficult to sketch this part of the discussion, and it need only be said that, taking pv and $\theta\phi$ diagrams—not practical diagrams, but assumed to illustrate the theory of entropy—the author discusses the meaning of each line or portion. In his final contribution he discusses conduction of heat, an important irreversible process, and shows that whenever there is heat-conduction there is growth of entropy throughout the volume of the conducting body. The growth of entropy in different parts of a furnace, in the boiler flues and tubes, in the boiler scale, in slide-valves, and in conduction from the jacket to the cylinder, and so on, is indicated in this connection, as all this growth means waste of energy, which it is the engineer's object to keep down. Wherever there is a temperature gradient there is a volume growth of uncompensated entropy. This is a convenient idea, as it shows that all conduction or radiation of heat involves waste, the power wasted depending solely on the temperature and its rate of decrease and the conductivity of the material. With regard to the physical meaning of entropy, it is shown that entropy is increased in different ways in different cases, and there is no one molecular change which corresponds with increase of entropy.—**J. Swinburne,** *Engineering, Sept. 4, 1903,* pp. 305–310; *Sept. 11, 1903,* pp. 337–341; *Sept. 18, 1903,* pp. 373–374.—*W.C.H.*

Valve Setting on a Double-eccentric Corliss Engine.

THERE are two general conditions under which two eccentrics are used on Corliss engines. The first is when a cut-off later than half-stroke is desired on any cylinder of a multiple - expansion engine. The second is when the engine is to run condensing. The range of cut-off for the ordinary form of Corliss gear is from the beginning of the stroke to half-stroke, or less. When a longer cut-off is desired, as is generally the case in a compound or triple-expansion engine, two wrist-plates may be used; one, moved by an eccentric with a small angular advance, has control of the exhaust valves, and gives release and compression near the ends of the stroke; and the other, moved by an eccentric with a negative angular advance, has control of the steam valves, which have a clearance instead of a lap. With this device the range of cut-off may be extended beyond half-stroke. The setting of the valves and eccentrics on a double-eccentric engine should be done by an experienced and competent engineer, who, with the aid of an indicator, will aim to get a smooth running engine with good indicator cards. The second case where two eccentrics are used is on a single-cylinder engine which runs condensing. In this case the steam valves have a lap, and are under the control of an eccentric with a positive angular advance, the same as for an ordinary single-eccentric engine. The eccentric which operates the exhaust valves is given a greater angular advance, in order to hasten the point of compression. Unless the point of compression occurs fairly early, there is not enough steam at the low pressure of exhaust to give the desired cushioning effect. Consequently many single-eccentric engines designed to run non-condensing, which have been converted into condensing engines, are found to run with considerable noise. Setting the valves on an engine of this type should be done with the aid of an indicator, the aim being to get a smooth, quiet running engine with a good indicator card. The variation in speed and exhaust pressure prevents the giving of any exact values for the valve setting. The higher the speed or the lower the condenser pressure, the greater will have to be the cushioning effect, and consequently the greater will have to be the angular advance of the eccentric, in order to get the desired point of compression. — **G. W. Bissell** and **H. W. Dow**, *The Engineer (N.Y.), Vol. XL., No. 17*, pp. 691, 692.

TRACTION.

High Speeds on Railways.

IN the records of the various fast runs which have been made throughout the country it has been very commonly stated that during parts of the run a speed of one hundred miles an hour has been reached, or even exceeded. A test on the Pennsylvania road not long ago would seem to indicate that such speed is very difficult to attain with a commercial locomotive. One of the fastest engines of that company, under the most favourable circumstances, was not able to reach that speed even when running light. The trial was made on a 25-mile stretch of track in very fine condition, with a slightly descending grade at the foot of which was a mile of absolutely level track, equipped with electric circuit breakers connected with a recording apparatus spaced by steel tape measurements. The chronograph used was one of great accuracy, but under such conditions the best that could be done over that mile was at the rate of 95·1 miles per hour. The trial started with eight coaches, and with each succeeding failure to obtain the desired record they were dropped one by one until finally the engine alone was used, and the above rate was the best obtained with several trials. It may well be doubted, therefore, whether the hundred-mile-per-hour rate has ever been reached, except in exceedingly rare instances, if at all. What may be the possibilities of the electric engine is as yet, of course, unknown. —*Edit. Rly. & Engg. Review, 1903, Sept.*, p. 660.—*C. S. L.*

Points and Crossing or Junction Diagram.

THE author refers to the want which is being felt for satisfactory tables and diagrams which would give at a glance the length of lead or the angle of a crossing for a junction whose radius of curvature is given, the calculation of which, when it is required, would be too great a task to undertake. Proceeding, he instances three methods of laying down points and crossings, viz. :—(1) To consider the switch a part of the curve of the junction, and for every junction to make a switch of the exact length required for that junction. (2) To set out the curve of the junction tangential to the main line (whether straight or curved), and at the point where the junction diverges from the main line to the extent of 4½ ins. to place the heel of a straight switch. The clearance at the heel of the switch plus the width of the rail is usually about 4½ ins. (3) To consider the switch as being straight, as in the previous method, and then to set out the curve tangential to the switch at its heel. With regard to the first method, railway companies, by whom it is adopted, have each their own particular system, and therefore no table or diagram can be prepared which would be of general use. The second method is one sometimes adopted for simplicity of calculation, but it has the disadvantage that the curve from the heel of the switch to the first crossing, when the rails are laid, is not a circular one as set out. If a switch is used which is too short for the curve, it has the effect of flattening the original curve as it leaves the switch, and quickening it as it reaches the crossing; or, if a switch which is too long for the curve is used, the curve is quickened as it leaves the switch and flattened as it reaches the crossing, the platelayer always adjusting the road so that it leaves the switch tangentially. By the third method the curve can be laid circular throughout, and a formula can be obtained which is quite as simple as for the previous method; but the centre line of the junction is not tangential to the centre line of the main line, it being tangential to a line parallel to it a few inches away, and to which amount the centre line of the junction may be deviated without

appreciably altering the general arrangement. The author next presents a formula from which the amount of deviation of the centre line of the junction from the centre line of the main line may be obtained, and continues: With regard to junctions where the main line is curved, whether the curves are of similar, or of contrary flexure, it may be proved mathematically that, for the same crossing on a given rail, the lead is practically the same as the lead for that crossing on a straight road, but measured at right angles to a radius of the main line at the heel of the switches, whatever combination of curves is used. After explaining the diagram which accompanies the paper, the author introduces several examples based upon conditions met with in the work of railway engineers, and in each instance provides a method of dealing with the exigences of the case, and a solution for the problems presented therein. A typical example is as follows: (4) "What is the flattest curve which can be obtained with a main line whose centre line is 80 chns. radius, to give a 1 in 8 diamond or obtuse crossing (curves of contrary flexure)?" The radius of the road on which diamond crossing will lie = 80 + ·085 = 80·085 chns.

$$\text{Equivalent radius off the straight} = \frac{R \times r}{R \times r}$$

$$21{\cdot}53 = \frac{80{\cdot}085 \times r}{80{\cdot}085 \times r}$$

$$(80{\cdot}085 + r)\ 21{\cdot}53 = 80{\cdot}085r$$

$$(80{\cdot}085 - 21{\cdot}53)\ r = 1724{\cdot}23$$

$$\text{therefore } r = 29{\cdot}445 \text{ chns.}$$

r = radius of the road upon which the diamond crossing lies; deduct ·085 chns. for the radius of the centre line, *i.e.* 29·445 − ·085 = 29·36 chns. The leads and crossings are the same as for a junction of 21·53 chns. off the straight.—**F. W. Atkinson,** *Rly. Eng., Vol. XXIV., No. 284,* pp. 280–283.—*C.S.L.*

The Electric Automobile as an Income Producer for Central Stations.

The advent of the automobile has been so recent that its possibilities have escaped the notice of central station managers. Within a few years, most of the transportation now carried on by horse traction will be carried on by automobiles. In this event, automobiles will prove a large income factor in the future. The profit to the central station from any service depends upon three conditions: (1) quantity of current consumed; (2) the time at which the current will be required; (3) the character of the load. With regard to (1) a light electric runabout will consume not less than 15 amps. on the four-hour rating, and will run about 40 miles on one charge. A 5,000-lb. truck will require a battery capacity of 50 amps. on the same rating; the mileage per charge at the present time is between 25 and 35 miles. With regard to (2) the conditions of service of automobiles will permit of their being charged at periods of light central station load when the station has plenty of power which the manager is unable to use, and, except in emergencies, there will be seldom any reason to charge many automobiles between 5 and 10 o'clock at night. The load conditions, therefore, represent a factor of almost clear profit. With regard to (3) the character of the load is absolutely ideal, being a regular and steady storage battery load without fluctuations. It has the further advantage of steadying the day voltage, the irregularity of which frequently gives fluctuations in the lighting load, in consequence of the power factor being so greatly in excess of the lighting factor. An impression prevails that automobiles are an expensive luxury, and, while this has been so in the past, it has been because machines have been inadequate to the work they were called upon to perform. Very few high-speed electric automobiles are at the present time on the market, simply because the manufacturers have no time to bring out new designs. The sooner central station managers investigate this matter seriously, the sooner they will obtain a valuable source of income, besides benefiting a growing industry.—**A. E. B. Ridley,** *Pacific Coast Electric Transmission Assoc. Rept. Elec. Rev., Vol. LIII., No. 1343,* pp. 322–3.

Mineral Oil in Road Improvement.

On all kinds of roads where oil has been applied the dust has ceased absolutely for an entire season after its application, and if renewed a second year has been abated for that year also and the following, whether then treated or not. These results never failed to follow persistent treatment with oil. In California waterspouts have subjected oiled roads to the severest tests. Mr. Theo. F. White, of San Bernardino County, tells of one storm in that county in which 10½ ins. of rain fell, 6 ins. of it in a single night. He says:

"The whole country was flooded, and it gave a good test of our oiled roads. There is a road running into San Bernardino on a grade of about 6 per cent. from a bench down into a creek bottom. The road had been oiled a second season, and there was a good oiled surface. The water rushed down the middle of that road, and it did not make a scratch. Between Pomona and Freeman a great quantity of water struck the oiled road at right angles at one point. On one side there was a margin of 6 or 8 ins. that the oil had not touched. The rain passed over the oiled surface, and when it came to that which was not oiled it cut it right out."

When oil was placed upon the surface of a road, if vehicles were allowed to run over it before it had sunk in and become thoroughly incorporated with the road material, the wheels picked up the oil and threw it in all directions. After experience had taught how to avoid this, no further serious difficulties manifested themselves. If the road is hard, like macadam, the oil must be put on when the surface has been heated by the sun. If the oil itself can be first heated, so much the better. Some of the oil will sink into the hard covering; the rest will remain upon the surface, and must receive a coating of sand or fine gravel. The oiled crust which results from such treatment will be partially the top surface of the original road and partially the new envelope. This can be still further built up by another oiling and another layer of sand. If the crust gets broken it should be repaired at once. Reliance must be upon an oil with an asphalt base.—**J. W. Abbott,** *Eng. News, Vol. L., No. 9,* pp. 190–192.

Tangential Traction.

A NEW system of electric traction, called "tangential traction," invented by two young Russian engineers, has been worked out and made practicable with the assistance of M. Dulait, of Charleroi. Tangential traction is based upon the direct application of polyphase currents. The characteristic feature of the system is the absence of the rotating motor in the car, and of any connection between the vehicle and the source of energy. The movement of the car is effected by the utilisation of a magnetic field for propulsion in either direction, the working of which may be described as follows: We know that in polyphase motors generally there is no electrical connection between the rotor and the stator. In consequence of the combination of the polyphase currents sent into the stator, a revolving magnetic field is produced which draws the rotor with it and imparts to it a rotary motion. If we develop along a plane surface the field magnet of such a motor, and suspend over it at a suitable distance its armature similarly developed, the rotary motion will be transformed into a rectilinear motion. This being granted, let us consider a vehicle placed on two rails. We will fix between the rails the stator, and suspend under the vehicle, above the stator, the developed armature called the propeller; this vehicle will be put in motion when a polyphase current is sent into the stator. Under these conditions the magnetic field no longer revolves, but travels along. This principle can never be applied practically as long as we keep to the arrangements generally adopted for polyphase motors, and the inventors have therefore been compelled to seek for a different arrangement enabling the air-gap to be increased. In any case the enlargement of the air-gap means an increase in the quantity of copper, which may become prohibitive. To meet this difficulty the inventors have had recourse to the following expedient: Instead of enlarging the whole of the core, they enlarge it at the poles by means of pieces of sheet-iron laid transversely, the core itself being laminated longitudinally. By this method the winding round the core retains its original length and the surface of the air-gap can be increased to the extent required.—*Anon., Elec. Rev., Vol. LIII., No. 1,343,* pp. 290, 291.

Freight Congestion.

BEFORE describing the classification of trains, yard classification must be considered, for that is where the trains are made up and some of the congestion occurs. When a train arrives at a terminal yard the cars are inspected and defects are looked for. Take a train of 30 cars, and this means 240 journals to inspect and the packing to renew or stir, or perhaps a brass to insert. The railroad expects three men to a train to do this work. Sometimes a brakesman does not correctly measure the distance before applying brakes, and damages cars so that it is necessary to "shop" same. This, of course, means delay to loaded cars. It is often from five to eight hours before the cars are given yard movement, the shifters being busy elsewhere. The operation of drilling cars goes on until they are all classified. When the train is *en route*, the principal and most exasperating delay is due to hot boxes. The retarding of one train blocks those following until the offending car can be cut out. Sometimes a journal burns off, letting the car down, and wrecking part or the whole of the train, and in the meantime tying up traffic. This hot-journal question is vexatious, but the trouble can be traced to robbing the axle-box of packing, or to inattention on the part of railroad employés. Cars loaded with coal, coke, stone, and sand are in the lead in this matter. At sidings the journal boxes and waste get full of dust and grit. No inspectors are provided at mine sidings, and if the employés of the coal concerns want to start a fire they just rob the journal box. Long hours for train crews is another cause of delays—they become sleepy and often run into trains ahead of them, wrecking both and tying up the traffic for hours. There are wrecks on the railroads every day that are only known to the railroad company. Much freight is damaged, freight and cars destroyed, and lading lost. The shortage of cars, due to so many being out of service, and of engines being crippled and in the shops, is another cause. The only way these and other delays *en route* can be remedied is to employ more car inspectors and efficient operative employés. The shops should have good all-round mechanics, crews should not be so long on the road, and more equipment should be forthcoming.—**Walter C. Herron,** *Proc. Eng. Soc. West. Pa., Vol. XIX., No. 1,* pp. 66–71.

MECHANICAL.

Notes on High-speed Tool Steels.

THE notes given in this paper represent data as to the use of high-speed tool steels in the works of the Union Pacific Railroad at Omaha. These steels are similar to the Mushet air-hardening steel, the principal difference being that a much higher temperature is used in the tempering process. The method of treatment consists in heating the tool up to about 2,000 degs. Fahr., then cooling rapidly down to about 1,700 degs. Fahr. in a lead bath, and then slowly in air or lime. High-speed steels are able to maintain a cutting edge even when operated at speeds producing a red heat, and unless such speeds and temperatures are maintained they do not give satisfactory results. The tools should be used only for roughing purposes, and the great economy resulting from their use appears when it is found that the forgings can be made with less care as to size, the roughing down to finishing dimension being made more rapidly and economically in the machining process than in forging. A spiral

Machine Tool.	Material.	Speed of cut.	Depth of cut.	Feed.	Weight of material removed per hour.
Lathe	Soft cast iron	74	$\frac{1}{2}$	$\frac{5}{32}$	—
Lathe	No. 1 Scrap iron ...	18	$\frac{3}{4}$	$\frac{1}{16}$	—
Lathe	No. 1 Scrap iron ...	26	$\frac{1}{2}$	$\frac{1}{8}$	—
Vertical boring mill	Tyre steel	40	$\frac{1}{8}$ roughing	$\frac{1}{2}$	—
Vertical boring mill	Cast iron	20	$\frac{3}{16}$	$\frac{1}{4}$	—
Horizontal boring machine ...	Cast iron (very hard)...	18	$\frac{3}{8}$	$\frac{1}{8}$	—
Driver lathe	—	24	$\frac{3}{8}$	$\frac{5}{32}$	90 lbs.
Planer	No. 1 Scrap iron ..	15	$1\frac{1}{8}$	$1\frac{1}{4}$	247–458 lbs.

turning from a locomotive tyre was made with high-speed steel at a speed of 24 ft. per minute, removing 100 to 120 lbs. per hour; while a heavy chip was taken at 18 ft. per minute, removing 450 lbs. per hour. This latter cut was too heavy for the powering of the lathe, and the rate could be maintained for only a short time, but the tool showed no signs of distress. The above table gives further data from the Union Pacific shops at Omaha.—**H. H. Suplee,** *Proc. Inst. Mech. Eng., Leeds Meeting, July, 1903.*

Defective Cranes.

THE ordinary electric crane will run no matter how badly it is put together, because the series motor that does the driving just goes ahead and sends things round. These motors are not intended to stall until they are burnt out; they just slow to a speed at which they can handle the load, and as long as the fuses and circuit breakers hold they will go. In some shops a fitted bolt is an ordinary black bolt driven into a hole punched or drilled the size of the bolt. Instead of using bevel washers on beam flanges the bolt head is bent to suit. Solenoids are bolted on cast-iron brackets, without a thought as to the magnetic short circuit so made. Ball-bearings designed to carry a heavy load have been made with chilled iron-ball races. Guide-frames for keeping a crosshead vertical have been built so light that it was impossible to keep them in shape; girder end connections so limber that the two end carriages could not be kept square; track wheels of grey iron; gear hubs and ends of bearings that rubbed together, left just as they came from the sand; light squaring shafting with a heavy foot that gave evidence of torsional deflection every time the machine was used; girders so shallow in proportion to span that the bridge motor pulled or pushed them out of line whenever in motion. In a through girder the trolley wheels ran on an angle iron, and whenever full load, or anything near it, was moved the projecting leg of the angle deflected and caused the wheel-tread to spawl off. A light crane is certainly desirable, but strength is necessary, and if the designer goes entirely by the calculated strains without knowledge of the service conditions, it is easy to pare down too close to the limit. The machine that works well in the machine shop may be a dismal failure in a steel mill if worked at full load.—**A. D. Williams,** *Amer. Machst., Vol. XXVI., No. 33,* p. 1156.

Metal Plating by Contact.

AFTER pointing out that with the contact methods so far used no practical results capable of industrial utilisation are possible, as the baths used in connection with aluminium contact were always of an acid character, the author suggests employing strongly alkaline baths, aluminium and magnesium being readily attacked by alkalis, and solid aluminates formed.—**A. Darlay,** *Elektroch. Zeitschr., Vol. X., No. 6, Sept., 1903,* p. 146.—*A. G.*

APPLIED ELECTRICITY.

Electric Rock Drills.

SMALL electric-drills require only from 1 to 2 h.p. to do work for which an air-drill requires from 5 to 10 h.p. It is rarely claimed for air-drills that they do cheaper work than hand-drilling, their use being only for more rapid production; but electric drills do their work more cheaply than it can be done by hand, some makers having figures to show work done at half the previous cost of hand-drilling. The first cost of an installation for electric drills should be half that for the same number of air drills; and, in addition, the shipping weight of an electric-drill plant is about one-quarter that of a corresponding air-drill plant, while the electric plant occupies much less space, and requires no special buildings or foundations. The assistance to ventilation urged in favour of air drills is hardly so valuable now as in earlier days; and to take the case of such deep mines as those of South Africa the stage is being reached where compressed and refrigerated air must be supplied to preserve a working atmosphere alone, and which it would be poor economy to use for drilling if other power were available. Electric drills are likely to be more handicapped than others by mishandling; rock drills are used with less care than any other machine; and electrical machinery is generally considered to require cleanliness and careful handling. As air-drill makers have been twenty-seven years in the market, and have made their machines as nearly foul-proof as possible, they have a long start over machines with obvious theoretical advantages, until

time has elapsed for a class of sufficiently educated electric-drill runners to have grown up.—**E. J. Munby, M.E.,** *Stev. Inst. Ind., Vol. XX., No. 3,* pp. 253–257.

The Evolution of the Starting Switch.

One of the defects of starters dating some years back was that of dividing up the resistance into too small a number of sections, the consequence being that the potential difference between the contacts was so great that disastrous sparking took place when working, and the acceleration of speed was too violent from step to step. Another error was that of dividing up the rheostat into equal parts as regards ohmic resistance. The most up-to-date manufacturers have now realised that about 8 to 10 contacts is the average number required for a satisfactory starter, and also that the resistance value of the sections should gradually decrease towards the "all-out," or armature contact. A necessity which made itself manifest was that of providing some mechanism for causing the switch arm to return to the "off" position should the supply of current to the motor cease. The best device for effecting this purpose is that of an electro-magnet, the winding on which is in series with the shunt coils of the motor, and against the poles of which the contact arm rests when in the running position. But this device does not prevent the motor from being overloaded. To prevent the motor suffering from excess current, a properly rated and easily renewed fuse should be provided, and where the cost does not render it prohibitive, a circuit-breaker, which should be set to open the circuit at about 15 per cent. less current than the fuse will carry. For currents up to 40 or 50 amps. the round-button contacts do fairly well, but a carbon point should be fitted to take the spark at the final break. For heavier currents, hard-rolled brass segment-shaped contacts should be provided. A satisfactory contact-making device is a spring-controlled block of carbon, which is finally cut out of circuit when the arm is in the running position. For currents exceeding 60 amps., the carbon block must be assisted by a copper contact piece, and the relative positions of the two must be such that the make and break on each contact is taken by the carbon. The trouble which has always existed in connection with wire-coil resistances is that they cannot be made really substantial without being bulky and expensive. Many attempts have been made to introduce a satisfactory motor-starter of the liquid type, but apart from its messy character, there is always the fact to be dealt with that every time the starter is used the level of the liquid must be slightly reduced owing to vapour being given off when it is heated. The writer has only recently found a satisfactory slow-starting attachment. The device in question is simple, it merely being necessary to pull out a knob from the case of the starter, and the attachment then automatically starts the motor at any rate of cutting out which may be desired. The above is combined with an automatic release action, and is described as Gibbing's patent.—**A. H. M.,** *Elec. Eng., Vol. XXXII., No. 10,* pp. 353–4.

Measurement of Polyphase Power.

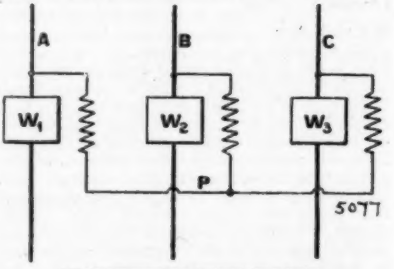
The two-wattmeter method of three-phase power measurement is but a particular case of a three-wattmeter connection with the resistance of the potential coil of one of the wattmeters reduced to zero. Hence, if it be shown that the sum of the readings of the three wattmeters connected, as in the adjoining diagram, gives the power, the truth of the two-wattmeter method is at once deducible." Let the three wattmeters, W_1, W_2, and W_3, be connected, one in each line, and let their potential coils be connected to a common junction, P. Then the sum of the three readings will give the total power, whatever the resistances of the potential coils may be. Let V_A, V_B, and V_C be the instantaneous potentials at A, B, and C respectively. Let V_P be the instantaneous potential at the common junction P. Let I_A, I_B, and I_C be the instantaneous currents in phases A, B, and C respectively. Then the total instantaneous power passing is equal to

$$V_A I_A + V_B I_B + V_C I_C \ldots . \quad (1).$$

The instantaneous power shown by the wattmeters is equal to

$$I_A (V_A - V_P) + I_B (V_B - V_P) + I_C (V_C - V_P) = I_A V_A + I_B V_B + I_C V_C - V_P (I_A + I_B + I_C).$$

But as the last term equals zero, this expression is the same as in (1); hence the sum of the readings of the wattmeters will be the total mean power passing. This proof is obviously perfectly general, being true for any wave shape or condition of balance of the circuits. Also, no assumption has



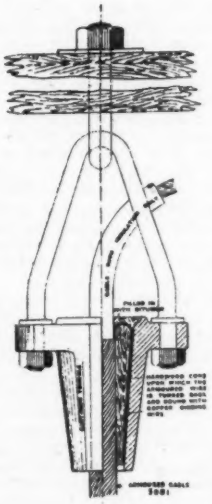
MEASUREMENT OF POLYPHASE POWER.

been made fixing the potential of the point P—*i.e.* the wattmeter resistances may have any values. If, for instance, we reduce the resistance of W_3 to zero—*i.e.* short circuit its potential coil by a wire—the other two wattmeters will read the total power. This is the usual two-wattmeter method, in which we have the potential at P, the same as that at one corner of the triangle of voltages.—**R. C. Clinker,** *Electrician, Vol. LI. No. 18,* p. 743.

Electricity in Mines.

Electric signalling in mines is still defective, due principally to cheap material and bad workmanship. Considerable trouble was experienced by the writer, owing to shaft wires breaking, and he finally put in a "multiple wire" cable, thoroughly insulated, and armoured with galvanised iron wires, freely suspended in the shaft

from a beam at the surface (see Fig.). Underground ball circuits usually consist of bare iron wire on insulators attached to the timbering or roof plugs. The chief difficulty is corrosion in wet places. Some pit water will corrode even copper wire, and in one instance this difficulty could only be overcome by keeping that part of the line greased. Bells, relays, and pushes should be strongly made, and enclosed in water-tight cases, so that they cannot be interfered with. Leclanche cells are generally used, but a great improvement would be effected by using secondary batteries, where there are facilities for recharging. Electricity is now generally utilised for lighting at the surface, and in many cases at the shaft bottom.



ELECTRICITY IN MINES.

Incandescent lighting is usually employed, though greater economy and better lighting would result from arc lamps. In the transmission of power electricity finds a large and useful field for application. The great objection to its adoption is the risk of a spark from a motor brush or an arc due to a cable breaking. Even in a fiery mine there must be enough air passing around the working places to enable men to stay their shift without ill effects, and in such an atmosphere it would be impossible for an enclosed c.c. motor to cause an explosion; and, moreover, an explosive mixture would first show on a safety lamp, and if it remained the workmen would withdraw, and the machine would cease working. The way to prevent risk of explosion is to ensure sufficient air to dilute and carry away any gas which may be given off. — **T. Campbell Futers,** *Elec. Rev., Vol. LIII., No. 1343,* pp. 287–288.

Electrical Plant Failures.

At the end of the paper, an analysis is given of the breakdowns which have occurred to several thousand machines, ranging in size from an 800-kilowatt dynamo to a ½-h.p. motor, the observations extending back for a period of about four years. The group of machines from which these statistics are prepared are under somewhat better than average conditions, so far as superintendence is concerned. Some causes of breakdown have been entirely eliminated, and others have been very much diminished. Further, owing to the elimination of a number of very bad machines, plants from which these statistics are prepared are considerably better than the average. Three tables have been prepared:—Table A is descriptive of the nature of the accidents. When an accident was of a compound nature, several parts being injured, each is included in the table, excepting those cases where the failure of one part is certain to follow on the failure of another. In Table B the point of origin of each breakdown enumerated in Table A is traced, and in Table C an analysis of the causes of the breakdowns is given. The preparation of these tables has been somewhat complicated by the complex nature of some of the derangements. In some cases, the derangements were not caused by any single fault, and for this reason, in preparing Table C, it was necessary to adopt a system of marks allocating the same number to each breakdown, but distributing them if more than one fault was the cause of the breakdown. Table B is the most interesting, as here the breakdowns mentioned in Table A have been analysed with a view to showing the portions of the machines at which the breakdown originated or the portions which by being faulty caused the breakdown. Table C sets forth as far as possible the conclusions reached as to the cause of breakdowns. Some of the headings in this table mean practically the same thing, but it seemed desirable to make out separate categories.— **A. C. Cormack,** *Electrician, Vol. LI., No. 17,* pp. 700-701.

Dielectric Hysteresis Losses and capacity of High-Tension Machines.

A comparatively accurate and convenient method for determining high dielectric hysteresis losses, as observed in the case of great strains on the dielectric, is afforded by applying the capacity to be tested to the high tension of a transformer, deducting the losses of the latter from the input. In the case of smaller losses, measurements are made immediately in the high-tension circuit by means of a watt-meter, the high- and low-tension coils of which are interchanged, glow lamps being used as shunt resistances. The losses observed are nearly proportional to the number of periods, a loss by the passage of the current being negligible as compared with dielectrical hysteresis. The capacity and, accordingly, dielectric "constant," is by no means a constant quantity for the tested material (micanite), being altered within appreciable limits according to the electrostatic strain. The variation of the capacity being unknown, the increase

in the dielectric hysteresis loss with tension cannot be determined in advance. The usual law, according to which the hysteresis loss is $= t E^2$, is only approximately true for materials the capacity of which is not altered, *i.e.* with small electrostatic strains. In high-tension machines with micanite tubes, the losses by dielectric hysteresis for higher strains on the micanite, are approximately proportional to the third power of the tension. In determining the efficiency of a high-tension machine the losses by dielectric hysteresis are absolutely negligible, relatively thick materials being mostly chosen on account of their safety against perforation. — **Dr. P. Holitscher,** *Elektrot. Zeitschr., No. 33,* pp. 635-640.—*A. G.*

LIGHTING, HEATING, and VENTILATION.

Emission and Transmission of Heat.

APPLICATIONS are made of the formulæ stated in previous chapters. The author considers first a room enclosed by walls, of which one only is exposed to the outside air; next taking two walls in immediate contact with one another, admitting that there is no sudden change of temperature in the passage of heat from the first to the second. Formulas applying to the transmission of heat through a wall exposed to the open air only hold good when all the other walls of the room may be considered as having approximately the same temperature as the air within the room, a condition which can hardly exist unless the first wall is the only one exposed to the outer air. When all the walls of the room are exposed to the outer air, all the inner surfaces are at temperatures differing very little from one another, and lower than that of the air in the room, and consequently for the same temperature of the inside air, the quantity of heat transmitted under the same circumstances per square foot per hour is smaller than in the case previously considered. This is the case with isolated buildings with only one room on a storey, and also with churches. Discontinuous walls and the transmission of heat through windows are next considered, after which the author takes up the transmission of heat through cylindrical envelopes, such as metal pipes traversed by steam and surrounded by some material of low conductivity. He afterwards deals with the diffusion of heat, the influence of the variations of exterior temperature on the quantity of heat transmitted through walls, intermittent heating, heat lost by walls during the suspension of heating, and the temporary heating of a room, concluding with some notes on the use of the formulas.—*Anon., Stev. Inst. Ind., Vol. XX., No. 3,* pp. 258-289.

Elimination of Platinum from Incandescent Lamps.

NUMEROUS attempts have been made to substitute a less costly metal for platinum. Platinum possesses special properties which make it very suitable for employment in the manufacture of incandescent lamps. Its co-efficient of expansion is approximately the same as that of glass, and its chemical properties are equally important from the point of view of sound jointing. The discovery of the properties of nickel steel by M. Quillaume is an interesting development, especially when it is considered that the lamp industry is menaced by the approaching exhaustion of platinum mines. It is possible to make great variations in the physical properties of nickel steel, and consequently to obtain an alloy having exactly the co-efficient of expansion of glass, so that it may be substituted for platinum to convey the current to the filament of the lamp. Another solution has been proposed which appears to give excellent results. The inventor does not accept the view that platinum is not replaceable, or rather that the joints made in employing other metals are never sound, and he utilises a special cement for filling the fissures which are developed between the metallic conductor and the glass of the bulb during or subsequently to jointing. This cement, of which the composition is kept secret, gives very good results, and ensures perfectly sound joints. The Compagnie Générale des Lamps à Incandescence, which employs this process, has been able to effect the entire elimination of platinum from the lamps manufactured. The cement has the consistency of soft wax, it is not prejudicially affected by exposure to air, and it does not melt under the influence of heat. It is placed in a chamber in the head of the lamp, through which pass the conductors conveying current to the filament. This solution is a real advance in lamp manufacture, an industry which was at the mercy of impurity contained in platinum, and, above all, found itself dependent upon a metal becoming more and more rare, and of which, consequently, the price augments day by day.—**A. Bainville,** *L'Electricien, Vol. XXVI., No. 660,* pp. 113-114.

The Relation of Sulphur in Lighting Gas to Air Vitiation.

AIR which is much vitiated by combustion of lighting-gas is distinctly oppressive. This effect is always very evident if the proportion of CO_2 has been raised to 30 or 40 vols. per 10,000 by combustion of gas. Pure CO_2 in the same proportion has no such effect, and is practically indistinguishable from pure air. Deficiency of oxygen to such an extent as occurs in the air of a room is also without sensible effect. The sulphur present in gas is probably the cause of the unpleasantness of air vitiated by the combustion of lighting-gas. The quantity of sulphur in ordinary lighting-gas is so small that this hypothesis may seem improbable. There is no doubt, however, that the sulphur is partly present as sulphuric acid, and in a particulate form. Sulphuric acid suspended in a particulate form has not the same specific taste as sulphurous acid, but is extremely irritating and unpleasant. In order to investigate the relation between the proportion of sulphur in lighting-gas and the unpleasantness of air vitiated by the products of combustion, I employed the following method. In one of two rooms (No. 1), the ordinary Oxford gas (which contained about 8 or 9 grs. of sulphur per 100 cub. ft.) was burnt. In the other room (No. 2) gas was used to which any required proportion of CS_2 vapour had been added. The CO_2

was determined at intervals in the two rooms; so that the degree of admixture of the products of combustion with the air was known. The following are the notes of an experiment:—*12.45 p.m.* Gas lit. In Room 1. Sulphur per 100 cub. ft. = 34 grs. *1.15 p.m.* Room 1. $CO_2 = 18{\cdot}5$ vols. per 10,000. Air unpleasant, causing irritation of air passages, and having a slight taste of SO_2. *1.30 p.m.* Room 2. $CO_2 = 20{\cdot}5$ vols. Air not appreciably unpleasant. *1.45 p.m.* Room 1. $CO_2 = 25$ vols. Sulphur = 46 grs. per 100 cub. ft. Air very unpleasant. Distinct irritation of air-passages, and slight irritation of the eyes. Acid taste. *2.50 p.m.* Room 1. CO_2 acid = 20 vols. Sulphur = 41 grs. per 100 cub. ft. Air irritating and unpleasant. *3.5 p.m.* Room 2. $CO_2 =$ 36 vols. Air slightly unpleasant, but less than in Room 1. *4.0 p.m.* Sulphur in ordinary gas = 8·7 grs. per 100 cub. ft. From the results as a whole there could be no doubt whatever as to the great superiority, from the standpoint of comfort and health, of gas properly purified over gas from which the CS_2 is not removed.—**J. S. Haldane, M.D., F.R.S.**, *Jnl. Gas Lighting, Vol. LXXXIII, No. 2,103*, pp. 564-565.

WATER AND SANITARY.

Composition of Sewage in Relation to Problems of Disposal.

An endeavour has been made by the writer to gather together the available information as to the composition of sewage, partly with a view to securing data which would be of general assistance in connection with various problems in sewage disposal, and partly with the view to seeing wherein further studies are necessary, in order to supplement data which are inadequate for allowing general deductions to be safely made. It may be said, in connection with the preparatory treatment of sewage preliminary to filtration, that we need more data regarding both the quantity and quality of suspended matters in various classes of sewage. This refers especially to the organic matter, and with particular reference to street refuse and mill wastes. The latter form a study by themselves, and in manufacturing cities should be studied separately from the domestic sewage. At present the relative amounts of organic matter in solution and in suspension, as they actually exist at purification works, are not well known, and no attempt in this paper has been made to estimate them, except so far as indicated by loss on ignition. Regarding preparatory treatment for sewage, it is believed that detailed studies of the changes in the organic matter will advance our practical knowledge of these processes, and lead to a more advantageous application of them. In the opinion of the writer, methods employed for studying the composition of sewage in its various phases have fallen somewhat into a rut; and it seems questionable to him whether the amount of added knowledge which may be obtained from a continuance of present methods year after year is going to be commensurate with the cost.—**G. W. Fuller**, *Tech. Qtrly., Vol. XVI., No. 2*, pp. 132-160.

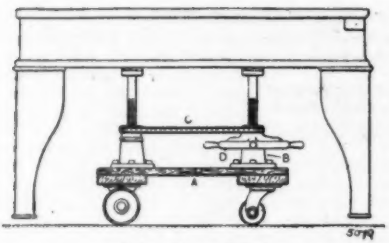
WORKS MANAGEMENT.

A Project for a Capitalised Labour Organisation.

The working man looks with suspicion upon any proposition the aim of which is to tie him to his employer by making him a small stockholder in his employer's business. If the capitalist is to establish with the labourer a relationship profitable to both, he must not only be perfectly fair, but he must remove from his proposition every suspicion of a trap. It often happens that of many things proposed no one is effective, but that a proper combination will establish the desired result. The object of this article is to bring together scattered elements in the form of a proposition intended to create a business relationship between capital as a whole and labour as a whole. This proposition takes the form of a capitalised labour organisation, the main object of which is to own good-sized blocks of stock in corporations employing labour of the kind which constitutes the organisation. If such a corporation can be formed and made successful, will it tend to eliminate, or even to diminish, labour troubles? The real answer will depend upon the good sense and the fairness of the promoters. If they promote an organisation which will be financially profitable to working men without restricting their freedom in any way, then there is no doubt but working men will join it in large numbers. But the crux of the whole matter is whether such corporations organised in different lines of manufacture would reduce the friction between capital and labour, and thus tend to prevent strikes and lock-outs. In the event of dispute an arbitration would be forced, and some of the officers of the labour corporation would probably be agreed upon as arbitrators. If they decided against the company so as to injure its money-making capacity, then they would cut off part of the dividends of the labour corporation, and cause injury to its stockholders. If they decided against the employés in such a way as to reduce wages, then they would injure part of the stockholders in the corporation. The probabilities are that they would use their influence to prevent controversy of any kind. These officers would learn that business methods are superior to warfare, and the working men would, through their pocket-books, learn the same thing. When they do learn this, then we may have industrial peace through the substitution of business methods for the present confusion.—**Casper L. Redfield**, *Eng. Mag., Vol. XXV., No. 6*, pp. 880-886.

A Lathe-Shop Truck.

The illustration shows a useful form of lathe-shop truck which is employed specially during the machining and the fitting up of small lathes and similar forms of machines. In erecting lathes, it is often found most economical to fit up certain parts in batches, and when one man has done his section of the work, the partly-finished frame is passed along by the benches to another fitter. The truck has only to be run in under a bed, the latter raised upon the ends of the screws until the feet just clear the floor, and then it may be rolled along to whatever position desired.



A LATHE-SHOP TRUCK.

The truck comprises a wooden frame *A*, travelling on two large wheels and on a smaller swivelling one. On the top of this frame three vertical brackets are attached with coach screws, or bolts, to take the vertical screws, of which there are three, one of them being behind the bracket *B*. This constitutes a triangular disposition, and as the three screws must rise simultaneously to lift the work evenly, a common pitch chain *C* drives from the sprocket-wheel on *B*, and transmits the motion evenly to two other wheels on the other brackets. The hand-wheel *D* is made in hollowed-out form, to go over the bearing bracket *B*, and it has four handles to turn by. If a large size of truck is contemplated, gearing may have to be introduced to gain sufficient power for raising the lathe. Several methods are available, but the simplest is to put a large bevel in the place of the hand-wheel and drive it by a small pinion, with its shaft lying horizontally and turned by a winch handle. No severe strain is put upon the operator, as would be the case in lifting a lathe by hand direct with two or three men, but the screws enable one man to raise the lathe slowly from its place on the floor to a distance of 2 or 3 ins., which is ample for the purpose of transporting it along.—**F. H.,** *Mech. Wld., Vol. XXXIV., No. 868*, p. 87.

MISCELLANEOUS.

A Rapid Blue-Print Frame.

Mr. C. H. Wills of Detroit, has produced a frame which can be handled with one motion and which automatically effects a perfect contact of surfaces, and is universally adjusted to the sun-ray direction. The frame wagon-track is of angle-iron, and is 21¾ ins. wide. The wagon wheels are 4 ins. tread, and 4¼ ins. flange diam. The wooden wagon-frame is of pine, and has turntable flanges on its top side. The moving part of the turntable runs on balls, and has two arms, which carry the board hinge-rod, on which the board can swing 45 degs. either way. The turntable turns all the way round, and is held by a spring latch working in a ring of holes in the base. The board is covered with a sheet of fine white felt ¼ in. thick, and is supported on the hinge-rod and held in place by a spring-latch which snaps into internal quadrant notches. The glass frame is large enough to shut down freely on the board. The glass when closed on the board lies flat on the felt sheet, which supports the weight of the glass, the sash, and part of the weight of the rocker arms. Rocker arms are fitted so that the sash can be freely lifted from either side. The weight of the sash, glass and rocker arms is effective to make a perfect contact on the elastic felt sheet on top of the board, and the glass is cushioned by the air trapped in the deep sash, so it shuts softly. Then the wagon is pushed outside the window on the rails, the turntable latch is pulled out and the board is turned to the sun; then the horizontal latch is lifted and the table is inclined to suit the light. With the paper used for rapid work two large blue-prints per minute can be produced when the sun shines.—**J. Randol,** *Amer. Machst., Vol. XXVI., No. 33*, pp. 1149–1150.

Chemical Reactions at Extremely High Temperature.

The author has tried to attain very high temperatures by burning aluminium in oxygen. In the Goldschmidt process, as is known, a temperature of about 3,000 degs. has been obtained in virtue of the indirect combustion of aluminium by means of combined oxygen. Burning the same in *free* oxygen should yield much higher temperatures, the theory giving for the former case about 5,117 degs., in the latter case 19,062 degs. In order to realise the purpose, aluminium powder is poured out gradually into a highly heated crucible, when it burns with a whistling noise on a strong stream of oxygen being led through it. The temperature obtained is at least as high as in the case of the electric arc, as may be inferred from the following data:—platinum, chalk and magnesia are melted and vaporised immediately, part of the chalk and magnesia combining to form aluminates, and the crucible being eventually perforated by the melting aluminium. Burning a mixture of aluminium with 15 per cent. graphite powder in oxygen would give aluminium carbide. Replacing the oxygen stream, after an extremely high temperature had been reached, by a stream of nitrogen, the nitrogen was found to combine with aluminium, giving a nitride, 38·57 per cent. of the aluminium used has thus been transformed into nitride. The combustion of aluminium at temperatures above 1,000 degs. takes place readily without any trace of carbon being left, both in carbon dioxide and monoxide. —**Prof. C. Zenghelis,** *Elektrochem. Zeitschr., Vol. X., No. 5, Aug., 1903*, pp. 109–110.—*A.G.*

Recent Advances in the Magnetic Separation of Ores.

The author describes the novel types designed by the Metallurgische Gesellschaft, A.G., Frankfurt-a/M. In the type shown by Fig. 1., being of a wide-spread application in Germany, the poles of the electro-magnet are arranged in a peculiar way, the principal pole *N* being placed at the centre, whereas the two other poles *S* are located to the left and right, as illustrated in Fig. 2. A very concentrated centre of magnetism is thus obtained, the lines of magnetic force acting over great length. The ore to be separated pours out

of the trumpet, falling on a continually rotating drum, and feeding the belt *B* placed below. The latter conveys the ore towards the centre of magnetism, rotating round the drum *R* where the ore leaves this strip. During its suspension in the air the ore is exposed to the magnetic attraction, when the non-magnetic particles fall from the belt, the other portions being attracted by the electro-magnet. The belt *B*, turning round the drums *N M*, passes directly below the pole of the magnet, and, according to their magnetic permeability, the particles of ore are more or less carried along, falling into one of the three lower reservoirs. The more magnetic the ore, the higher will be the amount of electric energy required for its separation. To separate spar-iron from the blend one hectowatt-hour per 1,000 kg. of ore are required, *i.e.* a little less than the consumption of energy of a 32-candle electric lamp per hour. The author further describes some other types especially designed for special purposes, in particular a novel apparatus, the "Separator Cylinder," by which separation is effected on the surface of a rotating cylinder, in virtue of induction phenomena.—**L. Fabre,** *L'Eclair. Electr., Vol. XXXVI, No. 36,* pp. 369–373.—*A. G.*

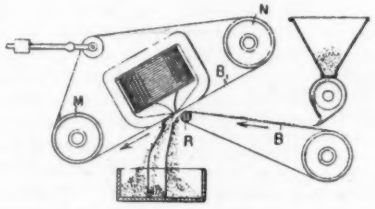


FIG. 1.

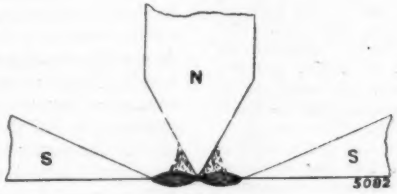


FIG. 2.

MAGNETIC SEPARATION OF ORES.

ABSTRACTORS.

W. N. Twelvetrees, *M.I.Mech.E., A.M.I.E.E.*
W. Craig Henderson, *M.A., D.Sc.*
Percy Longmuir, *Carnegie Research Scholar.*
E. J. Wade, *A.M.I.E.E.*
H. Beaumont Donaldson, *M. N. E. Coast Inst. Eng. and Shipblds.*
Dr. A. Gradenwitz.
C. S. Lake.
W. H. Wilson, *Salford Technical Schools.*
And Others.

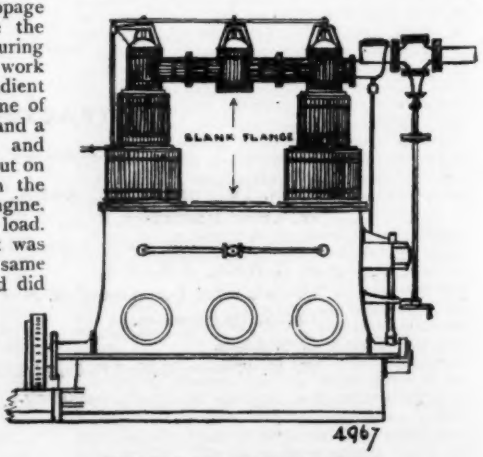
WORKSHOP PRACTICE.

This supplement is set apart for the description of new tools and appliances, and for discussion of matters relating to Works Management, Tools, the Machine Shop, Foundry, Pattern Room, and General Practice, both Mechanical and Electrical. It is of prime interest to Works Managers, Foremen, etc., from whom contributions, which are paid for, are cordially invited.

Experience with a new 30-b.h.p. Compound Engine.

The following experience was encountered during the extension of the electricity works where I was engaged. Part of the equipment was a new 300-b.h.p. compound three-throw single-acting engine, direct coupled to a dynamo. The set had been running on circuit a short time, but was shut down owing to a very heavy continuous knocking in the middle line of cylinders. On examination this was found to be due to the high-pressure trunk or hollow piston-rod having been smashed up owing to a nut which had worked loose getting jammed in one of the port-holes. The set had been put down to meet the extra winter load, and was required for the evening run the following day. There was not a spare high-pressure trunk in stock, but an order was dispatched to the makers immediately. This would mean, at the inside, a stoppage of three days, and in the meantime the supply would be at a reduced pressure during heavy load. However, the staff set to work right willingly, and the following expedient was resorted to :—The entire middle line of cylinders, valves, etc., was taken out, and a blank-flange put on the steam-top, and another one (made of ½-in. sheet iron) put on the crank-chamber top, as shown in the illustration. Steam was put on the engine, and it was given a short run without load. As everything appeared satisfactory it was put on load, and ran first class. The same evening it was put on heavy load, and did more than the legitimate share of work, and was run this way until the week-end, when the cylinder, etc., was replaced.

SHIFT-ENGINEER.



EXPERIENCE WITH A COMPOUND ENGINE.

Blow-pipes in Workshops.

A blow-pipe constitutes one of the indispensable accessories in the equipment of all brass-finishing workshops and modern tool stores. These are commonly used for a variety of purposes, such as tempering small tools, heating soldering irons, forging small drills, screw-drivers, etc. Most of the men have occasion to use, and quickly acquire skill in manipulating them. It is evident, then, that the conditions under which they work differs widely, which undoubtedly increases the liability of their accidentally causing a fire. At least, these conditions warrant precautions being taken against the possibility of such an occurrence. Generally speaking, the blow-pipes are simply placed upon a bench covered with a piece of sheet-iron, which is a very primitive arrangement. There is nothing

particularly dangerous about blow-pipes, but the variety of material that is used in conjunction with them—as, for example, soldering fluxes—combine to render them dangerous. The frequent relighting tends to the same effect. The following is a cheap and effective solution to these difficulties:—Mount the blow-pipes on an iron table, the top of which is best dished like a tray. Then erect the table on a sheet of iron covering a few square yards. Another plan is to sink in the floor a few flags covering the same area. An isolated position should be chosen for it, with a view to keeping inflammable materials of all kinds at a distance, and leaving the table more accessible for working at. If a small anvil and also vice were fixed on the table they would be found very convenient. Mechanics are so accustomed to having vices at their elbow, that they invariably find it awkward to work without them. Such an arrangement would be found doubly serviceable in electrical workshops, where so many soldered connections have to be made, and made neatly, too, which is not an easy matter. One often meets elaborate and expensive arrangements against fire being adopted, and yet by overlooking such simple things as blow-pipes the premises remain exposed to the evils that the proprietors unwittingly congratulate themselves they are free from. Q. E. F.

Taking out the Bulge.

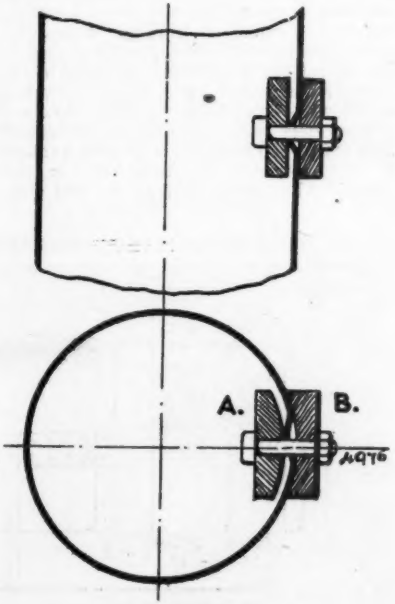
A riveted steel tube—50 ft. long, 21 ins. diameter, $\frac{3}{16}$ in. thick — got damaged, as shown, whilst being fixed up. It would not be passed with the indent, so we devised the following, to save taking down and the insertion of a new plate. Two cast-iron blocks, *A* and *B*, were made with radii less than that of the inside and outside of the tube. A $\frac{3}{4}$-in. hole was drilled through the centre of the indent, and the blocks and a bolt inserted, as shown. By screwing the nut hard up we effectually took out the depression, which, fortunately, was near the bottom, afterwards filling up the hole with a flush-headed rivet. G. C.

An Expansion Trouble.

A little difficulty recently presented itself, due to the expansion of a boiler of a traction engine we were repairing. The cylinder of the engine was fixed at one end of boiler and the crank-shaft at the other. We set the valve with a $\frac{1}{16}$-in. lead at each end, and fastened down the steam-chest cover. When steam was up we could not understand why, when we ran the engine slowly with any weight on it it always stopped on one centre. We examined the valve by taking off the steam-chest cover, and found that it had no lead on the side *nearest* the crank-shaft but a full $\frac{1}{8}$ in. on the *other*. When the boiler had cooled down we found the valve same as we had set it, showing that an allowance should have been made for expansion between cylinder and crank-shaft, consequent upon the elongation of the boiler. J. H. T.

Grinding Reamers.

A simple method of getting the best possible cutting clearance for expanding and adjustable inserted blade reamers is as follows:—Draw the blades in to the



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SUP

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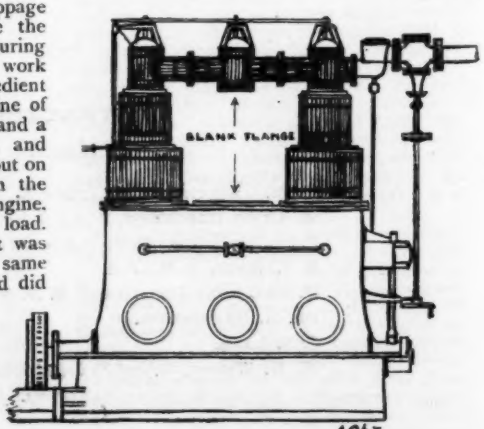

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Blow-pipes in Workshops.

A blow-pipe constitutes one of the indispensable accessories in the equipment of all brass-finishing workshops and modern tool stores. These are commonly used for a variety of purposes, such as tempering small tools, heating soldering irons, forging small drills, screw-drivers, etc. Most of the men have occasion to use, and quickly acquire skill in manipulating them. It is evident, then, that the conditions under which they work differs widely, which undoubtedly increases the liability of their accidentally causing a fire. At least, these conditions warrant precautions being taken against the possibility of such an occurrence. Generally speaking, the blow-pipes are simply placed upon a bench covered with a piece of sheet-iron, which is a very primitive arrangement. There is nothing

particularly dangerous about blow-pipes, but the variety of material that is used in conjunction with them—as, for example, soldering fluxes—combine to render them dangerous. The frequent relighting tends to the same effect. The following is a cheap and effective solution to these difficulties:—Mount the blow-pipes on an iron table, the top of which is best dished like a tray. Then erect the table on a sheet of iron covering a few square yards. Another plan is to sink in the floor a few flags covering the same area. An isolated position should be chosen for it, with a view to keeping inflammable materials of all kinds at a distance, and leaving the table more accessible for working at. If a small anvil and also vice were fixed on the table they would be found very convenient. Mechanics are so accustomed to having vices at their elbow, that they invariably find it awkward to work without them. Such an arrangement would be found doubly serviceable in electrical workshops, where so many soldered connections have to be made, and made neatly, too, which is not an easy matter. One often meets elaborate and expensive arrangements against fire being adopted, and yet by overlooking such simple things as blow-pipes the premises remain exposed to the evils that the proprietors unwittingly congratulate themselves they are free from. Q. E. F.

Taking out the Bulge.

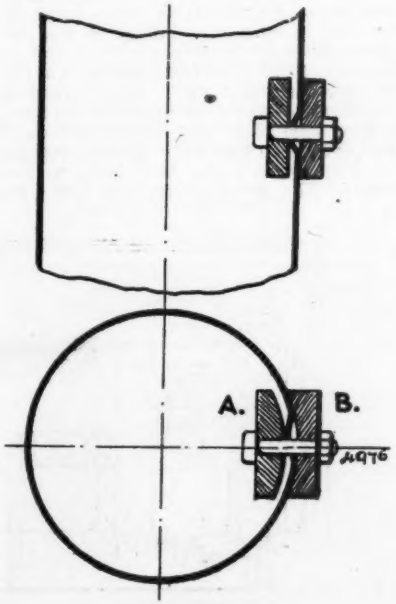
A riveted steel tube—50 ft. long, 21 ins. diameter, $\frac{3}{8}$ in. thick — got damaged, as shown, whilst being fixed up. It would not be passed with the indent, so we devised the following, to save taking down and the insertion of a new plate. Two cast-iron blocks, *A* and *B*, were made with radii less than that of the inside and outside of the tube. A $\frac{3}{4}$-in. hole was drilled through the centre of the indent, and the blocks and a bolt inserted, as shown. By screwing the nut hard up we effectually took out the depression, which, fortunately, was near the bottom, afterwards filling up the hole with a flush-headed rivet. G. C.

An Expansion Trouble.

A little difficulty recently presented itself, due to the expansion of a boiler of a traction engine we were repairing. The cylinder of the engine was fixed at one end of boiler and the crank-shaft at the other. We set the valve with a $\frac{1}{16}$-in. lead at each end, and fastened down the steam-chest cover. When steam was up we could not understand why, when we ran the engine slowly with any weight on it it always stopped on one centre. We examined the valve by taking off the steam-chest cover, and found that it had no lead on the side *nearest* the crank-shaft but a full $\frac{1}{8}$ in. on the *other*. When the boiler had cooled down we found the valve same as we had set it, showing that an allowance should have been made for expansion between cylinder and crank-shaft, consequent upon the elongation of the boiler. J. H. T.

Grinding Reamers.

A simple method of getting the best possible cutting clearance for expanding and adjustable inserted blade reamers is as follows:—Draw the blades in to the



TAKING OUT THE BULGE.

lowest limit below the standard size and lock them firmly. Now place the reamer in a grinder; grind the blades and body of the reamer supporting the blades, for reamers up to 1 in. about ·0625 below the standard size, and for reamers above 1 in. and up to 2 ins. about ·125 below the standard size, finishing with a very light cut. The reamer is now complete, with its cutting edges all equal. Now, by simply expanding the reamer to the standard size, we get the ideal clearance for a finishing reamer, viz., about 3 degs., accounted for by the blades being ground on the arc of a circle smaller than that in which they have to work.

GAUGER.

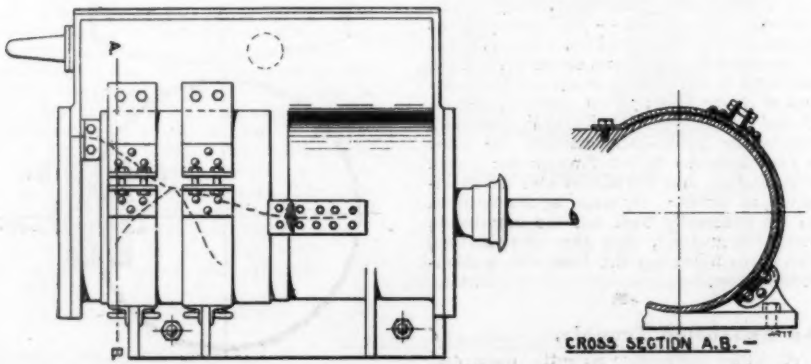
[Some little difficulty is sometimes experienced in bringing the blades back to standard size; care must be taken to ensure this.—ED.]

Repair to Steam-engine Cylinder.

The cylinder shown on sketch got cracked for three-quarters of its length through a large stud dropping out of the piston, and jamming against the cylinder. Strange to say, the piston did not damage the cylinder end in any way, all the injury being sustained by the cylinder flange and top. The patchwork is as follows:—Over the major part of the crack a ¼-in. steel plate was placed (previously bent to fit). To hold this in position a couple of straps were made, both being in two pieces. The straps were 5½ ins. and ½ in., and were secured to bed of cylinder by two steel pins driven through lugs riveted to the strap, and also through lugs on cylinder bed, as shown. The straps did not meet, but were tightened up by ⅝-in. bolts, thus pressing the plate covering the fracture tighter against the cylinder. The ends of the straps on the valve-chest were held by a couple of ⅝-in. set screws. Covering the tailing-off part of the fracture was a steel plate 11 ins. by 4½ ins. by ⅜ in., joggled over centre fillet of cylinder, and overlapping slightly the larger patch-plate. This was secured to the cylinder by means of ten ⅝-in. set screws, as shown. Next a small piece of steel plate was cut, and bent to lie on to cylinder top, and rise up tight against inside of flange. Secured by two ½-in. set screws, this did its duty all right, as did the rest of the patchwork. Red lead jointing was used between the plates and the cylinder. The engine on which this temporary repair was executed is a stationary one—stroke, 3 ft. 6 ins.; diameter of cylinder, 1 ft. 6 ins.; steam pressure used on patchwork, 16 per square inch—60/68. This doubtful repair stood very well until a new cylinder was got ready. EVAN FLEMING.

Another use for Squared Paper.

In working out the weights or strengths of various articles it is often necessary to know the area of their cross-section. In the case of irregularly-shaped sections, and where a planimeter was not available, the following method has been found very useful. A series of horizontal and vertical lines $\frac{1}{10}$ in. (or any other convenient distance) apart, are drawn on a piece of drawing or tracing paper, thus dividing it up into squares



REPAIR TO STEAM-ENGINE CYLINDER.

each $\frac{1}{100}$ of a square inch. A drawing or tracing of the section is taken and laid under or over the squared tracing paper and the number of squares covered by it is counted. This, divided by 100, gives the area in square inches. The actual area of the section can be in this way very accurately determined.

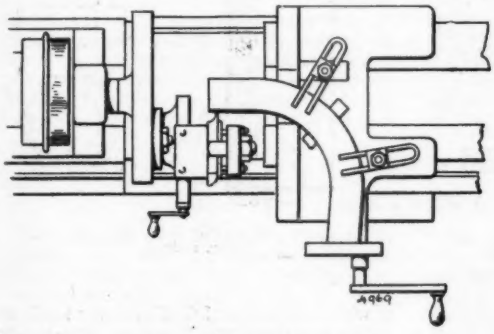
J. E. L.

[Squared paper may be bought ruled in $\frac{1}{10}$ ths and $\frac{1}{8}$ ths.—ED.]

Cutting Thread on Elbow-pipe.

The other day there was a 6-in. cast-iron bend came in to be screwed at one end; the length of each leg was about 2 ft. 6 ins., which was much too large for the biggest lathe to swing. The job was successfully accomplished in the following manner. The slide-rest was taken off the saddle, and the bend was laid on the saddle and packed up level with the lathe centres, and strongly bolted down, as shown in the illustration. The top slide of the slide-rest was bolted to the lathe face-plate in the position shown in the sketch, and a turning tool fixed in the tool-holder. The saddle was self-acted along, and as the tool travelled round the end of the bend the cut was put on by moving the tool nearer in towards the centre of the face-plate by means of the slide-rest bolted on it. When the end of the bend was turned the proper gear was put on for screw-cutting, and the turning tool was replaced by a thread tool and the thread was cut in a similar manner. A small hole was drilled for the point of the tool to drop into each time, as it would have been almost impossible to withdraw it while the lathe was running.

H. W.

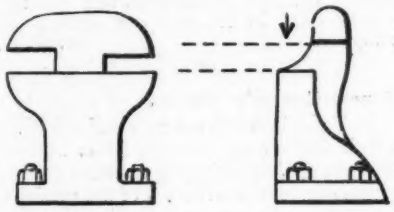


CUTTING THREAD ON ELBOW-PIPE.

A Stretching Block.

The illustration below shows a block for stretching cast-iron rails or bars. The workman places his bar in the position of the dotted line, presses on the outer end of the bar and taps with a hammer on the part indicated by the arrow.

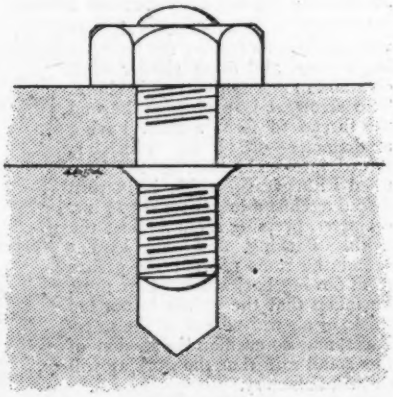
J. H.



A STRETCHING BLOCK.

Studs in Large Commutator Flanges.

In the flanges of large commutators it is necessary that the studs should be as nearly perpendicular as possible. Now, it is not easy to tap a number of holes in succession and insure this being so. A good plan is to leave a V-shaped collar on the

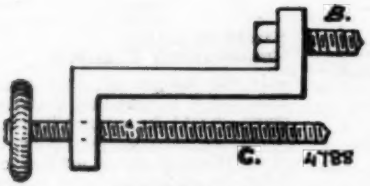


COMMUTATOR STUDS.

stud, and make a counter-sink in the hole to fit it. Then, when the stud is turned "home," the collar helps to straighten it. When drilling these, the top flange is liable to shift slightly. This is best avoidable by tapping the first hole drilled, and placing a set screw in it until the drilling is completed. W. W.

Screw-Cutter's Guide.

At Fig. 1 is shown a simple and effective attachment for any ordinary lathe. It consists of a Z-shaped forging fastened on the cross-slide between the V's of the carriage by set screw *B* in such a position that the point of the knurled-headed screw *C'* shall act as a stop and prevent the cutting tool from entering too deeply the work being operated upon. It is much better and more satisfactory than chalking the feed screw at every cut, as is usually done. J. G.



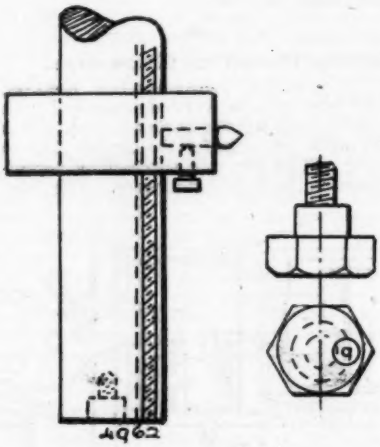
SCREW-CUTTER'S GUIDE.

A Small Hydraulic Screw Press.

The hydraulic screw press shown at Fig. 1 was designed for forcing out bolts, straightening frames, and other similar work common in locomotive repair shops. The screw *A* is prolonged beyond the thread to form a ram, having a diameter of 1¼ in., which is forced into a chamber at the base filled with grease, which is in turn forced against a larger ram of 2¼ ins. diameter, pressing it out against the work. Packing and cup-leather round the rams prevent the grease from flowing backwards. Care must be taken that the grease is not too thick, or air will collect in the interstices, and so cushion the motion of the small ram that the working will be unsatisfactory. G. E.

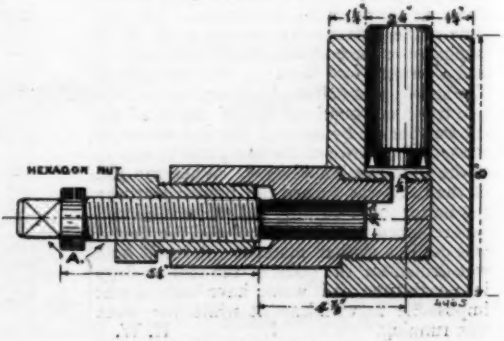
Taper Boring.

A simple attachment easily fitted to an ordinary boring-bar is shown in detail at Fig. 1, whereby holes of any given taper can be accurately and satisfactorily bored. The end of the boring bar is drilled and tapped, and also counterbored to receive a steel stud,

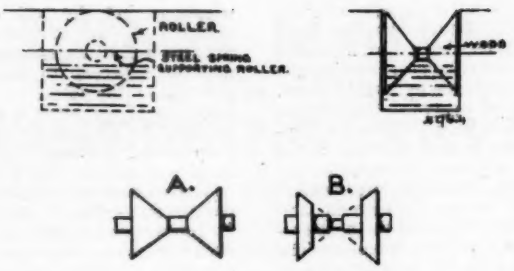


TAPER BORING.

of which a number of duplicates are made of varying eccentricity. These are inserted in the bar; the hexagon head provides for the use of a spanner and gives at the same time a greater surface, whilst the neck ensures a better bearing. F. B.



HYDRAULIC SCREW PRESS.



LUBRICATING PLANERS.

Lubricating Planer Slides.

Among the machine tools I am in charge of is a 6-ft. planer with V-slides. These slides are lubricated by running over wooden rollers fixed in oil-wells, cored in the bed, as shown. These have given trouble through refusing to turn and flat places wearing on them. A new set of rollers was obtained and given careful attention, but still they were not reliable. To overcome this, they were put in the lathe and turned from shape *A* to that shown at *B*. They were then replaced, and have since worked satisfactorily. There is very much less friction now, due to the different parts of the roller having different velocities, and the oil is still carried up to the top of the slide, whence it runs down to the lower parts that are not now oiled by the roller itself. C. E. S.

[Double-coned rollers of cast-iron can be recommended as both reliable and effective. —ED.]

REVIEWS.

Handbuch der Elektrotechnik. Heinke Vol. IX. (Leipsic: S. Hirzel.) *Electric Motors and Power Transmission*, Niethammer and Schultz; xiii., 221, and 195 pages; 1901; 18 marks. Vol. XII.: *Telegraphy and Telephony*, J. Noebels, A. Schluckebier, and O. Jentsch; xviii. and 793 pages; 1901; 30 marks. Vol. I.: Part I., *Electro-Physics*, C. Heinke; xiv. and 408 pages; 1902; 10 marks.

Before considering in detail these three further instalments of Heinke's great work on electro-technology, we may note that in matter, printing, and the excellence of the illustrations, they maintain the high standard set in Vol. IV., which was the first to appear and has already been reviewed in our columns.

We will first consider the last published of the three volumes, "Heinke's Electro-Physics," as it forms the introduction to the whole work. The first 124 pages are devoted to an extremely valuable and interesting historical sketch of the development of the science of electro-magnetism, from the work of Gilbert in 1628 down to the year 1900. The second chapter discusses the various theories which have been propounded for the explanation of electro-magnetic phenomena. After a discussion of the value and functions of scientific theories in general, the older electrical theories—under which term the author includes everything prior to the Faraday-Maxwell theory—are very briefly considered. The outlines of the latter theory are then clearly and succinctly set forth, including Oliver Lodge's developments. The conception of cyclic motions introduced by Helmholtz and Hertz is then dealt with, and the ionisation theories of Arrhenius, Ostwald, Nernst, and others. The remainder of the volume is occupied with a descriptive account of electro-magnetic phenomena.

Vol. IX. consists of two separate contributions by its two authors. The first portion, by Dr. Neithammer, opens with a short historical account of the development of the continuous-current motor, after which the theory is very briefly but clearly set forth.

A good many omissions might be noted of workers who have contributed to the development of the continuous-current motor. For example, the important theoretical work of Ayrton and Perry is not even mentioned. The different types of continuous-current motor are discussed, with methods of starting and speed regulation. The next chapter is one of the most important in the

book ; it consists of a full descriptive account, with a wealth of illustrations and sectional drawings, many of which have the dimensions marked on them, of recent types of continuous-current motors constructed by leading firms. With the exception of a very brief description of the Lundell motor, only firms on the Continent of Europe are represented, and, to the English-speaking engineer, the value of this chapter lies in the excellent presentation which it gives of recent Continental, and especially German, practice in the construction of continuous-current motors. The author next passes to the consideration of the alternate-current motor, both polyphase and monophase. A short historical sketch is first given. Bailey's motor, which, though it only existed as a rough model, was the first polyphase motor ever constructed, ought certainly to have been mentioned. The theoretical treatment is clear and thorough. Steinmetz's work is frequently referred to ; but with this exception, and that of a brief reference to Blondel's graphical methods, this part of the work deals only with the investigations of German physicists and engineers. Dr. Niethammer's contribution to the volume concludes with an excellent descriptive account of recent alternate-current motors by the leading Continental, and a few American, manufacturers.

The second portion of the volume, by Herr Schulz, opens with a discussion of the general principles of continuous- and alternate-current motor construction ; but this portion is very brief, and is written from the point of view of the workshop, while Dr. Niethammer's exposition of theory is addressed rather to the scientific engineer and to the student who desires to become a scientific engineer. The practical design of motors is briefly considered in this portion of the work. Methods of testing are also discussed, and the different ways of connecting and setting up motors for use. A final chapter, dealing with the transmission of power by electro-motors, consists of accounts of various installations, followed by illustrated descriptions of cranes and various machine tools driven by electric motors.

The three authors who have collaborated in the production of Vol. XII. are all officials of the German Post and Telegraph administration, and their united work forms a most comprehensive treatise on telegraphy and telephony, which, while giving special prominence to present German practice, also describes in detail the more important systems and appliances employed for overland telegraphy and telephony in other countries. Brief historical sketches are given of the development both of telegraphy and telephony, but the bulk of the volume is devoted to the consideration of present practice and of recent developments which may be expected to find a place in the practice of the future. The formal completeness of the work is maintained by the inclusion of the subject of submarine telegraphy ; but, although some of the apparatus employed, such as Kelvin's syphon-recorder, is described in considerable detail, the treatment of this subject is meagre in the extreme. It appears somewhat regrettable that, in a work which is otherwise so exceptionally complete, a section has not been added on submarine cable practice by a writer as fully versed in this subject as the authors show themselves to be in overland telegraphy.

The next section is devoted to the description of telegraphic apparatus. This is very well and fully done, and includes such recent inventions as those of Pollak and Virag. The apparatus employed in military field telegraphy is dealt with in this section. A considerable amount of space is devoted to the treatment of multiplex systems. Wireless telegraphy receives its meed of notice, the Marconi and Slaby-Arco systems, and the Braun transmitter, being described in detail. The telegraphic section of the work concludes with an account of the various instruments and methods of measurement employed. The section on telephony also opens with a short historical introduction, and this is followed by a discussion of the physical principles involved. The various forms of microphonic transmitters and telephone receivers are described in great detail, together with all the various subsidiary apparatus employed in connection with them. Telephone exchange systems, including automatic systems, are very fully discussed, with numerous illustrated diagrams, and a description of Poulsen's telegraphone, with the different developments introduced by Pederson and others. The construction and maintenance of telephone lines are then dealt with. The materials of construction are very fully considered, and the methods of determining the tension of suspended wires are gone into. The laying of cables underground and under water is briefly touched upon. Methods of localising faults are very fully dealt with. The volume concludes with an appendix giving a textual reproduction of the principal laws and enactments affecting telegraphs and telephones in Germany.

All the three volumes, like the one previously reviewed, are furnished with very complete indices, both of names and subjects, which greatly enhance their value.

G. W. DE T.